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NE Nevada Engineering Kathy Mrotek

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Parsons Brinckerhoff	Mina Hydrologic and Drainage Evaluation Report Rev 00	April 26, 2007	07-00022

Section I. Submittal Information (includes above information)

Submittal Description and Revision Summary for Entire Submittal:

This is the final submittal for the Mina Hydrologic and Drainage Evaluation Report and includes the revised alignment received from BSC as well as the field data collected in Schurz area.

This report delivery contains figures in .JPG format and report, attachment and appendix in PDF format.

Special Instructions:

Section II. Data File Information (Add lines below if needed for additional files. Indicate "Last item" or "End of list" on last line used.)

Filename	Rev.	File Size	Description (File description and revision summary for file)	Application and Version/ Add-in or Extension and Version
Fig1_1_MinaReport_17x22_20070425.jpg	00	31,570 KB	JPEG Image	MS office 2000 and above-Window Picture and Fax Viewer
Fig3_1_Mina_hdsc_nws_noaa100yr06hr_11x17_20070425.jpg	00	5,713 KB	JPEG Image	MS office 2000 and above-Window Picture and Fax Viewer
Fig3_2_Mina_hdsc_nws_noaa100yr24hr_11x17_20070425.jpg	00	7,215 KB	JPEG Image	MS office 2000 and above-Window Picture and Fax Viewer
Fig3_3_Temporal Distribution Regions.pdf	00	161KB	PDF format figure	Adobe Acrobat 7.0
Fig3_4_Mina_PrecipStations_22x34_20070425.jpg	0B	13,984 KB	JPEG Image	MS office 2000 and above-Window Picture and Fax Viewer
Fig3_5_Mina_StreamGaugeStations_22x34_20070425.jpg	00	13,975 KB	JPEG Image	MS office 2000 and above-Window Picture and Fax Viewer
Fig3_6_Mina_Verified_Veg22x34_20070425.jpg	00	31,686 KB	JPEG Image	MS office 2000 and above-Window Picture and Fax Viewer
Fig3_7_Mina_Soils_22x34_20070425.jpg	00	50,336 KB	JPEG Image	MS office 2000 and above-Window Picture and Fax Viewer
Fig5_1_MinaReport_11x17_2007425.jpg	00	14,162 KB	JPEG Image	MS office 2000 and above-Window Picture and Fax Viewer
Fig5_2_MinaReport_11x17_2007425.jpg	00	14,705 KB	JPEG Image	MS office 2000 and above-Window Picture and Fax Viewer
MinaHydroDrainEval_042607.pdf	00	201KB	Hydrologic evaluation report	Adobe Acrobat 7.0

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Mina Attachment.pdf	00	5,860KB	Preliminary Hydrologic Study for Major Drainage Crossings Report – PDF format	Adobe Acrobat 7.0
Mina Appendix calcs - Final.pdf	00	2,681KB	Supporting calculations/analyses	Adobe Acrobat 7.0
Report Cover – Cover page.pdf	00	699KB	Report cover - Front	Adobe Acrobat 7.0
Report Cover – Back PB.pdf	00	675KB	Report Cover - Back	Adobe Acrobat 7.0
Report Cover - Spine.pdf	00	68KB	Report Cover - Spine	Adobe Acrobat 7.0

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Section III. Metadata

☒ **GIS Metadata** All GIS data is preferred in ArcGIS9.1 UTM, NAD1983, Zone11, Feet.	Projection: NAD 1983 UTM Zone 11N
	Datum: D_North_American_1983, Semimajor Axis: 6378137.00 Semiminor Axis: 6356752.3141403561 Inverse Flattening: 298.25722210100002
	Zone: 11N
	Units: Feet
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07-00022

Phase 1 Hydrologic and Drainage Evaluation Report Mina Rail Corridor

Task 2.3: Preliminary Investigations for Hydrologic and Drainage Evaluations for Conceptual Design

Rev. 00

07-00022

Prepared by:

PB 100 YEARS

Prepared for:

BECHTEL SAIC COMPANY, LLC

Nevada Rail Project – Hydrologic Analysis

NN-SRA-00207

April 26, 2007

HYDROLOGIC AND DRAINAGE EVALUATION REPORT

MINA RAIL CORRIDOR
YUCCA MOUNTAIN PROJECT, NEVADA

Subcontract No. NN-SRA-00207

April 2007

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ATTACHMENT

Acronyms and Abbreviations

Original Name	Acronym
American Association of State and Highway and Transportation Officials	AASHTO
American National Standards	ANS
American Railway Engineering and Maintenance-of-Way Association	AREMA
Bechtel SAIC Company	BSC
Bureau of Land Management	BLM
Mina Rail Corridor	MRC
Comprehensive Environmental Response, Compensation, and Liability Act	CERCLA
Civilian Radioactive Waste Management System	CRWMS
Code of Federal Regulations	CFR
Curve Number	CN
Department of Energy	DOE
Digital Elevation Model	DEM
Digital Image Rectification System	DIRS
Digital Video Disk	DVD
Energy Research & Development Administration	ERDA
Environmental Impact Statement	EIS
Executive Order	EO
Federal Emergency Management Agency	FEMA
Federal Highway Administration	FHWA
Geographic Information System	GIS
Global Positioning System	GPS
Hydrologic Engineering Center	HEC
National Environmental Policy Act	NEPA
National Flood Frequency	NFF
National Flood Insurance Program	NFIP
National Oceanic & Atmospheric Administration	NOAA
National Pollutant Discharge Elimination System	NPDES
Natural Resources Conservation Service (an agency of US Department of Agriculture)	NRCS
Nevada Administrative Code	NAC
Nevada Department of Transportation	NDOT
Nevada Revised Statutes	NRS
North American Datum	NAD
North American Vertical Datum	NAVD
Soil Conservation Service	SCS
Triangulated Irregular Network	TIN
United States Bureau of Reclamation	USBR
United States Geological Survey	USGS
United States of America Corp of Engineers	USACOE
Universal Transverse Mercator	UTM

1.0 INTRODUCTION

1.1. PROJECT BACKGROUND

The U.S. Department of Energy (DOE) is studying two corridors in Nevada for possible construction of a rail line to transport spent nuclear fuel and high-level radioactive waste to a proposed repository at Yucca Mountain, Nevada. The corridors, both 0.25 mile-wide, are referred to as the Caliente and Mina corridors. DOE may eventually select one alignment within one of these corridors for the rail line. This report identifies and examines the hydrologic and drainage conditions along the Mina corridor.

The Mina corridor originates at the terminus of the Union Pacific Railroad at the Fort Churchill siding near Wabuska, Nevada. From that point, the corridor extends southeastward along various alternate alignments until it intersects with the Caliente corridor either along the Caliente Alternative Alignment GF4 at Station 42710+00, or along Caliente Common Segment CS4 at Station 14146+54. From these intersections, the segment, common to both the Caliente corridor and the Mina corridor, continues southeastward where it terminates at Yucca Mountain near the southwest corner of the Nevada Test Site (NTS). Hydrologic and other studies of the segment common to both the Caliente corridor and the Mina corridor have already been completed and are contained within the Hydrologic and Drainage Evaluation Report, Rev. 0, dated June 27, 2005 (see Figure 1-1).

The Mina Rail Corridor (MRC) will cross numerous streams and small drainages. Most of these are ungaged, meaning that no measurements of flood flows have ever been recorded. In fact, few stream flow measurements have been made in this arid region. Thus there is a need to use computer models to simulate the hydrologic process that can result in flooding to a railroad corridor. The general goal of this modeling is to determine a reliable estimate of flood discharges and stream elevation so that the railway can be placed above flood elevation, provide adequate waterway crossings, and not be damaged by stream erosion and other stream forces.

The design of the MRC will follow standards of the transportation industry as compiled by the following institutions:

- American Railway Engineering and Maintenance-of-Way Association (AREMA)
- American Association of State and Highway and Transportation Officials (AASHTO)
- Federal Highway Administration (FHWA)
- Nevada Department of Transportation (NDOT)

According to these references, the 50-year flood frequency is often used for evaluating the hydrologic reliability of rural transportation corridors. Other flood frequencies that are important in the design of transportation corridors include the 100-year frequency in accordance with the National Flood Insurance Program (NFIP) and the 500-year frequency for bridges that are scour vulnerable. In addition, arid region stream morphology is associated with more frequent floods in the range of the 10-year flood.

1.2. PURPOSE AND SCOPE

The objectives of the hydrologic investigations are to:

1. Support the preparation of an Environmental Impact Statement (EIS) by identifying locations of significant and unusual flood hazards, i.e., those parts of the corridor potentially affected by severe flash floods, extensive mudflows, and areas of standing water such as playas.

2. Provide data and analyses to support route selection and alignment optimization and the conceptual design of a rail line within the proposed Mina Rail Corridor.

3. Specify and apply a watershed model approach, based on a 100-year flood recurrence interval, to identify flood-runoff characteristics of the watersheds along the proposed Mina Rail Corridor. Results from this work will be used by others in the conceptual, preliminary, and final design of the drainage structures along the alignment under consideration.

4. Develop surface drainage recommendations and move forward with the modeling in Phase 2 of the project.

5. Provide services to analyze and review drainage structures during the construction phase of the railroad.

2.0 DRAINAGE REGULATIONS

2.1 DRAINAGE REGULATIONS

The proposed Mina Rail Corridor (MRC) originates near Wabuska, Nevada, about 11 miles north of Yerington, Nevada, and about 45 miles northwest of Walker Lake and the Hawthorne Army Ammunitions Depot. The alignment travels southeast through the Walker River Paiute Reservation on the east side of Walker Lake, turns south at Mina, Nevada, goes through the Soda Spring Valley, and continues east toward Tonapah before turning south again and passing near the towns of Goldfield, Scottys Junction, Lida Junction, and Beatty. The alignment terminates at the Yucca Mountain Repository Site. There are federally protected lands in the area and the corridor traverses four counties (Lyon, Mineral, Esmeralda, and Nye); consequently, there are federal, state, and local drainage laws, regulations, and rules that may impact drainage design along the corridor. This section attempts to identify the most relevant of these regulations. Other regulations may become applicable during the process of this Work and, if so, will be addressed as needed.

2.2 FEDERAL REGULATIONS

Federal regulations include the Code of Federal Regulations (CFR), Executive Orders (EO) and department and agency rules. The following lists the most significant of these regulations and Table 2-1 summarizes the federal regulations.

- 44 CFR Part 9 – Floodplain Management and Protection of Wetlands

  This regulation affects the rail corridor elevation design and hydraulic structure sizing for segments crossing floodplains. If wetlands are impacted, protection and/or replacement measures are necessary.

- 44 CFR Part 60 – Criteria for Land Management and Use

  This federal regulation concerns floodplain management and flood-prone and mudslide areas.

- 44 CFR Part 65 – Identification and Mapping of Special Hazard Areas

  This federal regulation concerns flood hazard identification, revision, and review.

- 10 CFR Part 1022 – Compliance with Floodplain/Wetlands Environmental Review Requirements

  This part establishes policy and procedures regarding the Department of Energy's (DOE's) responsibilities under EO 11988 and EO 11990, including: (1) DOE policy regarding the consideration of floodplain and wetland factors in DOE planning and decision-making; and (2) DOE procedures for identifying proposed actions located in a floodplain or wetland, providing opportunity for early public review of such proposed actions, preparing floodplain or wetland assessments, and issuing statements of findings for actions in a floodplain.

To the extent possible, DOE shall accommodate the requirements of EO 11988 and EO 11990 through applicable DOE National Environmental Policy Act (NEPA) procedures or, when appropriate, the environmental review process under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. 9601 et seq.).

- EO 11988 – Floodplain Management
- EO 11990 – Protection of Wetlands
- DOE Order 6430.1A – General Design Criteria

  The provisions of this Order apply to all Departmental Elements except as otherwise provided by statute or by specific delegation of authority from the Secretary of Energy, and all contractors and subcontractors performing work for the Department whose contract may involve planning, design, or facility acquisitions. This includes DOE-owned, -leased, or -controlled sites where Federal funds are used totally or in part, except where otherwise authorized by separate statute or where specific exemptions are granted by the Secretary or his designee.

- DOE-STD-1020-94 – Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy (DOE) Facilities

  This design and evaluation criteria control the level of conservatism introduced in the design/evaluation process such that earthquake, wind, and flood hazards are treated on a consistent basis.

- Bureau of Land Management (BLM) Right-of-Way regulations

  This is the BLM rules of rights-of-way. It may be applicable to channel realignments.

The current scope of this project only addresses the 100-year flood event with various durations depending on hydrologic area and other factors. Sediment transport is to be addressed only in those areas where such transport will affect the design of the MRC improvements.

Table 2-1: Referenced Flood Events and other Information Referenced in Federal Regulations

Regulations	25-yr	100-yr	500-yr	PMF	Sediment Transport	Notes
DOE Order 6430.1A	X	X	X	X	X Also implied	References: EO 11988, EO 11990, 10 CFR Part 1022, UCRL 115910
DOE-STD-1020-94				X	X	
EO 11988		X				
EO 11990						Wetlands
44 CFR Part 9		X	X		Implied by references to other regulations	
44 CFR Part 65		X	X		X	Also FEMA Design Criteria Chapter 10
10 CFR Part 1022		X	X			
40 CFR Part 264.18		X				
40 CFR Part 264.193	X					Based on a 24 hr storm event
40 CFR Part 270.14		X				Requirement for flood hazard delineation map and consideration of other "special flooding"

2.3 STATE REGULATIONS

State regulations are administered through different state agencies. The following lists the relevant state agencies and regulations.

Nevada Department of Conservation and Natural Resources

- NRS 543 CONTROL OF FLOODS

  This NRS chapter concerns the cooperation of the state of Nevada with federal agencies.

Nevada Division of Water Resources

- NRS 535 Dams and other obstructions

  This regulation affects dams that 1) are 20 feet or more in height as measured from the downstream toe to dam crest, or 2) if less than 20 feet in height, impound more than 20 acre feet of water. If either criterion applies, permit must be obtained from the State Engineer to appropriate, store, and use water impounded or diverted by the dam. Section 5.7.5 identifies that there are several reservoirs in the MRC watersheds that may affect the drainage design of the railroad.

Nevada Division of Environmental Protection

- NPDES Permit (NRS 445A)

  This regulation requires that the quality of existing waters of the State be maintained during construction and operation of the proposed railroad. As such, Best Management Practices (BMPs) should be implemented so that rail corridor activities do not propose any threat to water quality. In addition, channel and culvert design and construction must consider erosion control measures.

Nevada Department of Transportation

- Terms and Conditions Relating to the Drainage Aspects of Right-of-Way Occupancy Permits

  This concerns discharges and/or impacts to the NDOT properties and right-of-ways.

2.4 LOCAL REGULATIONS

The MRC traverses Lyon, Mineral, Esmeralda, and Nye counties in Nevada.

Lyon County Code

- Section 10.12.10 Specific Plan

  This section covers financing plans and performance standards for flood control and drainage facilities.

- Section 11.07.07 Storm and Surface Water Drainage

  This section covers requirements for stormwater protection with respect to development.

- Title 12 Flood Control

  This section covers flood control facilities.

Mineral County Code

- Title 17 Development Code

  This code requires any development to mitigate negative flood impacts.

Nye County Code

- Chapter 15.12 Flood Damage Prevention

  This code requires any development to mitigate negative flood impacts.

Esmeralda County

- No building permit requirement.

3.0 LITERATURE AND DATA REVIEW

3.1 HYDROLOGIC REPORTS AND ANALYSIS

Several analyses and reports have been prepared that present hydrologic analysis of areas in and around the MRC watershed area. Many of these analyses and reports are documented in the Hydrology Report prepared in 1990 for the initial conceptual design of the Yucca Mountain access railway (KJC, 1990). Floodplain mapping information collected from these existing studies is included in the hydrologic data DVD that contains relevant collected data for this hydrologic study.

The most pertinent of these studies include KJC, 1990, and others listed herein.

3.1.1 Hydrology Report - Yucca Mountain Rail Access Study – Caliente Route, Kennedy/Jenks/Chilton, December 1990 (KJC, 1990)

This study was prepared to provide hydrologic data to be used in the conceptual design of the Yucca Mountain access railway. Some of the alignments analyzed in this study are similar to those being analyzed in the current study. This study determined peak 100-year runoff flow rates for about 150 separate watersheds using the USACOE HEC-1 computer program. For watersheds from 1 to 5 square miles, the study used two separate regression equations generated from the HEC-1 analysis: one equation for alluvial watersheds with poorly defined channels, and one for watersheds with typical branching stream networks. The study also provided information and 100-year peak flow rates for FEMA regulated floodplains and expected flood levels in Mud Lake.

3.1.2 United States Geological Survey (USGS) Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States (USGS, 1994)

This study presents equations for estimating 2-, 5-, 10-, 50-, and 100-year peak flow rates for ungaged sites on unregulated streams that drain watersheds of less than 200 square mile. Specifically, the MRC watersheds are located almost exclusively within two of the USGS designated Hydrologic Flood Regions. These regions overlap with one region located at or below 7,500 feet in elevation (Region 6) and the other region (Region 1) located above 7,500 feet in elevation. The 7,500-foot elevation threshold represents an estimated elevation above which large flood events caused by thunderstorm events are unlikely to occur. This is thought to be due to the reduced amount of energy and moisture available at higher elevations for the convective process and the greater density in ground cover which enhances infiltration and reduces runoff. Region 6 (including the overlaying Region 1) encompasses almost one-half of the State of Nevada and the western half of the State of Utah.

The only MRC watershed area not located in Regions 1 or 6 is the area south of latitude 37° (along MRC segment CS6). This watershed area is located in Region 10 which encompasses the southern quarter of the State of Nevada (all areas south of 37° latitude) including all of Clark County. The equations presented in this study show that peak discharges in Region 10 are much higher than peak discharges in Region 6 for the same drainage area, especially for larger watersheds. This study also suggests that, while the region boundaries are explicit for purposes of equation generation, the actual hydrologic boundaries are not necessarily distinct. Thus, areas near these boundaries, such as is the case for the above described MRC segment in Region 10, should be analyzed using both region equations and weighted accordingly.

3.1.3 Clark County Regional Flood Control District Technical Memorandum No. 2, WRC Engineering, Inc., December 1989 (WRC, 1989)

This study provides a comprehensive analysis of rainfall statistics and patterns in the Clark County, Nevada area. The study provides meteorological analysis of storm types occurring across the southern Nevada area and includes analysis of rainfall data from several stations located within the Nevada Test Site.

3.1.4 National Oceanic & Atmospheric Administration (NOAA) Atlas-14 (NOAA, 2004)

NOAA Atlas 14 is the most current and in-depth study of precipitation patterns and statistics for the southwestern United States. This study is a replacement for NOAA Atlas 2 which was published in 1973. NOAA Atlas 14 includes over 20 years of additional precipitation data subsequent to NOAA Atlas 2. Presented on Figures 3-1 and 3-2 are NOAA Atlas 14 precipitation maps for the State of Nevada for the 100-year storm event with durations of 6 hours and 24 hours.

Appendix A.1 of NOAA Atlas 14 includes an analysis of temporal distributions of heavy precipitation in the NOAA Atlas 14 study area. For this analysis, the study area was divided into two sub-regions based upon seasonal weather patterns. In Nevada, the boundary between general or frontal precipitation events (in the north) and convective or thunderstorm precipitation events (in the south) roughly extends from the middle of Nye County at the California border to the middle of Lincoln County at the Utah border. In general terms, this follows the similar region boundary discussed in the USGS report (USGS, 1994). This study concluded that maximum precipitation events in the general precipitation area were dominated by cool season (winter) precipitation while maximum events in the convection precipitation area occurred in the warm (summer) season as shown on Figure 3-3. This finding can be applied to the selection of temporal distributions of precipitation and the determination of modeling parameters to estimate runoff characteristics for design purposes.

3.1.5 Federal Emergency Management Agency (FEMA) Flood Insurance Studies

For the purposes of this study, FEMA, USGS, and other sources of data were obtained and reviewed to determine whether flood maps or studies have been prepared within the MRC watershed. Based on this research, the Mina Rail Corridor is not impacted by any current FEMA studies conducted in the area.

3.1.6 Final Hydraulic Design Report for Amargosa River Bridge (WRC, 1993)

This study provides an analysis of peak flows of the Amargosa River where it crosses U.S. 95 north of Beatty, Nevada. The analysis used various methods of peak flow estimation to establish the 100-year peak flow for an NDOT bridge replacement project.

3.2 HYDROLOGIC DATA

3.2.1 Precipitation Data

Daily precipitation data in the MRC watershed is available from weather stations (See Figure 3-4). These weather stations have more than 30 years of daily data such as the Goldfield, Scottys Junction, Tonopah, Mina, Thorne, and Schurz weather stations. Analysis and regionalization of this data is including in the NOAA Atlas 14 (NOAA, 2004). Additional precipitation data is available from the Nevada Test Site weather stations.

3.2.2 Streamflow Data

Relevant streamflow data in and near the MRC watershed is available from five stream gage stations (see Figure 3-5). These stations do not have sufficient data from which a statistical streamflow relationship can be defined. Analysis of data from these stations through 1985 is presented in USGS, 1997. The gaging data is contained in the hydrologic data DVD for this project.

3.3 HYDROLOGIC RELATED DATA

3.3.1 Topography

USGS has 30-meter digital elevation model (DEM) data available for the entire study area. In addition, USGS 7.5 minute quadrangles are also available for the entire study area.

3.3.2 Aerial Photography

Detailed aerial photography at a scale of 1 meter per pixel from 1999 is available from the USGS for the entire study area excluding the Nevada Test and Training Range.

3.3.3 Vegetation and Land Use

Detailed vegetation and land use coverage data is available from the USGS for the entire study area. In addition, more current and detailed provisional vegetation and land use coverage data is available from the USGS's Cooperative Southwest Regional Gap Analysis Program (USGS, 2004), which is displayed in Figure 3-6.

The vegetation and land use data was field-verified and utilized to determine runoff modeling parameters. Field verification identifies changes of vegetation condition and land use since the time the USGS data coverages were developed.

3.3.4 Soils

Soils information for the entire study area is available from the Natural Resources Conservation Service (NRCS) and is shown on Figure 3-7. Soils information for the study area was obtained as a GIS coverage that included soil type, identification number, and composition type. The information also included the SCS soil classification (Hydrologic Soil Groups A, B, C, D) and will be used to determine the runoff potential for the soils in the modeling phase of the project. Hydrologic Soil Groups range from A, low runoff potential, to D, high runoff potential, with B and C in between.

4.0 REGIONAL PRECIPITATION

4.1 INTRODUCTION

The watersheds that contribute runoff to the MRC are located in an area generally described as the Great Basin. The climate of this area consists mainly of warm to hot, dry summers and cool to cold, dry winters. In hydrologic terms, this climate results in two distinct hydrologic seasons. During the late spring to early fall season, precipitation patterns are dominated by convective, short duration, high intensity thunderstorms. During the late fall to early spring season, precipitation patterns are dominated by long duration, low intensity, general storms that may fall in the form of rain or snow. Convective and general precipitation events result in runoff characteristics that differ between smaller watersheds (up to 200 square miles in area) and larger watersheds (greater than 200 square miles in area). For smaller watersheds, summer thunderstorms will dominate the peak runoff rates occurring in the tributary channels and washes. However, as watershed areas increase, general storm events eventually generate the peak rates of runoff. For all watersheds, the volume of runoff will generally be greater for the general (winter) storms than for the convectional/thunder storms (summer). These differences will require hydrologic analysis of both convective and general storms to determine the controlling event for peak runoff rates and volumes.

4.2 CHARACTERISTICS OF FLOOD EVENTS IN NEVADA

A majority of the large flood causing events in and around the MRC on smaller watersheds are the result of summer thunderstorms. These short duration, high intensity events have caused significant flood damage on various watersheds both in and surrounding the study watersheds. Examples include:

- A flood event on August 1, 1968, on an Amargosa River tributary near Mercury, with a recorded peak flood flow of 3,430 cubic feet per second (cfs) from a 111-square mile area.

- A flood event on July 29, 1975, on Caselton Wash near Panaca, with a recorded peak flood flow of 1,710 cfs from a 70-square mile area.

- A flood event in July 1984, on Yucca Wash near Mouth on the Nevada Test Site, with a recorded peak flood flow of 940 cfs from a 17-square mile area.

- A flood event in July 31, 1968, on a Patterson Wash tributary near Pioche, with a recorded peak flood flow of 49 cfs from a 5-square mile area.

Historic floods in the larger watersheds have been caused by both short duration, high intensity, summer thunderstorms and by long duration, continuous winter general storms, including rain on snow events. For the larger watersheds (greater than 200 square miles in area.), historic peak flood flows are influenced by general storm events. Examples of these types of events include:

- A flood event on February 24, 1969, on the Amargosa River near Beatty, with a recorded peak flood flow of 16,000 cfs from a 470-square mile area.

- Several flood events on the Meadow Valley Wash near Caliente draining 1,670 square miles, occurring in 1910, 1938, and the most recent event of January 10, 2005. The estimated peak flood flows from these events were approximately 11,000 cfs, 15,000 cfs, and about 3,000 cfs, respectively.

- A flood event on March 11, 1995, on Forty Mile Wash at the Narrows (258 square miles), Nevada Test Site, with a recorded peak flood flow of 3,000 cfs.

4.3 MOISTURE SOURCES AND FLOW PATTERNS

There are three important sources of moisture in the lower atmosphere that can supply sufficiently "rich" moisture quantities needed to generate large precipitation events over the subject watersheds. The first source is from "summer monsoon" air originating in the Gulf of Mexico. This air moves in a broad path from the Gulf of Mexico across Mexico, and then northwesterly toward Arizona and Utah, and furnishes abundant moisture for the many July and August rain showers in the states of Arizona, New Mexico, Utah, and Colorado, particularly in the mountainous areas. The very western edge of this monsoon flow moves northward over southeastern Nevada, but with less frequency than the main flow over Arizona and Utah. In addition, a moisture gradient exists in the monsoon flow that delivers less moisture to the north and central areas of Nevada than is provided along the southeastern border of the state.

The second source of moisture-rich air originates in the Gulf of California. This air flows directly from south to north and covers over 400 miles or so to southern Nevada. This moisture pattern occurs infrequently as compared to the summer monsoon moisture pattern. In addition, the moisture content of this air decreases as the air mass moves from south to north.

The third source of moisture originates in the eastern Pacific Ocean. During the winter months, this significant source of moisture produces heavy rainfall in western California and heavy snowfall in the Sierra Nevada Mountain range. Moisture that remains in the air flow after crossing the mountains reaches Nevada and produces general storm rainfall over the lower elevations for periods of 24 to 96 hours. Smaller periods of more intense precipitation are some times imbedded in these storms which, when combined with saturated ground conditions, create the winter flooding events characteristic of the large watersheds in the study area. At higher elevations, this moisture also precipitates as snow that can and has resulted in historic flooding events from "rain on snow." On rare occasions during the summer months, warm moist air can move from the warm eastern Pacific Ocean above the limited passages that avoid high terrain in Southern California and produce general storms over broad areas for extended periods of time of 12 to 36 hours.

In addition to these three sources, a fourth source of moisture occurs in rare instances. This source is from dying hurricanes and tropical storms that generally occur during the month of September. These storms are similar to the eastern Pacific Ocean moisture flows in that they produce general storms that extend for 12 to 36 hours over a broad area. These storms, however, do not generally produce intense, flood-causing rainfall within the subject watersheds.

4.4 GENERAL STORM EVENTS

General storm events in Nevada are typically 2 to 4 day events with heavier precipitation occurring for only a short (3- to 6-hour) period during the storm events. NOAA, as part of their updated precipitation Atlas 14 for the southwest United States (NOAA, 2004), analyzed over 1,800 storm events to determine temporal distributions of general storm events (see Figure 3-2). This analysis shows that in over 45% of the general storm events, the period of heaviest rainfall occurred during the first 24 hours, with a majority of the heavy rainfall occurring in the first 12 hours. In general, the largest general storm flood events in central and southern Nevada have occurred after the initial storm precipitation has saturated the ground surface prior to the heaviest portion of the general storm event. The areal extent of the general storms occurring in southern and central Nevada has typically ranged from 1,000 to 10,000 square miles.

4.5 CONVECTIVE EVENTS

Convective (thunderstorm) events in Nevada are typically high intensity, short duration (1 to 3 hour) storms occurring between the early spring to early fall months. NOAA, as part of their updated precipitation Atlas 14 for the southwest United States (NOAA 2004), analyzed over 2,100 storm events to determine temporal distribution of thunderstorm events (see Figure 3-1). This analysis shows that in over 50% of the storm events, the period of heaviest rainfall occurred during the first one and one-half hours, with a majority of the heavy rainfall occurring in the first hour. For these events, the ability of the ground surface to absorb and infiltrate rainfall is small as compared to the intensity of rainfall at the height of the storm event. These conditions provide the "flash flood" events typical of the smaller watersheds in the study area. The areal extent of thunderstorms typically covers less than 200 square miles.

4.6 FREQUENCY OF EVENTS

The aridness of the MRC watershed area is directly related to the lack of storm events occurring on a yearly basis. In fact, many areas will not experience a large storm event for several years. However, when storm events do occur, they tend to be severe and cause significant runoff to occur in the area washes and channels. The main risk to MRC facilities is thus governed by large, single events as opposed to more frequent, continuous events.

Another risk to MRC facilities near dry lake beds is the runoff volume collected in the dry lakes from long duration general storms or large, intense storm events with a short duration.

There are some high elevation areas of the MRC watersheds that experience more continuous runoff during the winter and early spring months due to snowmelt and continuous low intensity rainfall. The peak runoff rates from these conditions are much lower than those caused by higher intensity general storm events and high intensity thunderstorm events.

5.0 MRC WATERSHEDS HYDROLOGIC CONDITIONS

5.1 TOPOGRAPHY

The general topography of the MRC watersheds consists of higher altitude mountainous areas draining to alluvial outflows and dry lake beds. Elevations in the watersheds range from above 10,000 feet in the northern and mid-Nevada mountains to about 4500 feet in the alluvial flats around Yucca Mountain. Most of the mountain ranges exhibit a north-south orientation.

5.2 SOIL DRAINAGE CHARACTERISTICS

The soil characteristics of the MRC watersheds are reflective of the geology of the area. Much of the lower elevation watersheds consist of "desert pavement," the layer of gravel or stones left on the land surface in desert regions after removal of the fine material by wind. In some areas, the soils are underlain by cemented hardpans (cemented by iron oxide, silica, calcium carbonite, or other substances). Several of the watersheds include areas of rock outcrops and larger stones and boulders. Soils classified in Hydrologic Soil Groups C and D predominate in most of the drainage areas. These soils have reduced infiltration capacity as compared to more pervious Group A and B soils.

5.3 LAND USE

Over 90% of the MRC watersheds consist of undeveloped government and private land. Typical uses of this land are for military exercises, open range, ranching, recreation, and small areas of agriculture. A small portion of the study area is used for residential, commercial, and industrial purposes. Except for some small watersheds in the developed areas of the study area, this level of development has minimal effect on peak runoff rates in the area.

5.4 VEGETATION

Vegetation in the lower elevations of the southwestern watersheds consists primarily of sparsely spaced Sonora-Mojave area creosote-bush and bursage desert scrub. The remaining low elevation watersheds of the MRC consist of sparsely spaced big sagebrush shrubland and salt desert scrub. The transition area to the higher watershed elevations is vegetated with sparsely spaced piñon-juniper and mountain sagebrush. The highest elevation watersheds are vegetated with dense ponderosa pine and piñon-juniper. There are small pocket areas in the watersheds that are vegetated with pasture type grasses. The overall scarcity of vegetative cover is consistent with the poor soils in the area and lack of vegetation sustaining precipitation.

5.5 MRC WATERSHED HYDROLOGY AND DESCRIPTIONS

5.5.1 MRC Watershed Hydrology

The Great Basin, which covers most of Nevada, is a contiguous watershed that has no natural outlet to the sea – surface runoff either infiltrates into the ground or evaporates. The Great Basin is part of the Basin and Range Physiographic Provence (Stewart, 1980). Similarity of the physical environment throughout the region allows general discussion of surface water along the Mina Corridor. This general discussion of all the areas is referred to simply as "the region."

Consistent with the Great Basin, hydrographic basins of the region have internal drainage controlled by topography. Almost all streams in the region are ephemeral. Runoff results from snowmelt and from precipitation during general storms that occur most commonly in winter and occasionally in fall and spring, and during localized thunderstorms that occur primarily in the summer (DOE, 1988). Much of the runoff quickly infiltrates into rock fractures or into the dry soils, some is carried down alluvial fans in arroyos, and some drains onto dry lake beds where it may stand for weeks as a lake (DOE, 1986). These dry lake beds exhibit a perennial water deficit that has characterized Nevada, at least in historic times (French, et al., 1984).

Floods on alluvial fans and dry lake beds in the region will have an impact on portions of the drainage design of the Mina Rail route. The potential exists for sheet flow and channelized flow through arroyos to cause localized flooding throughout the Mina Corridor. There are some hydrologic studies (see Section 3.1) for portions of the area within the MRC, which delineate floodplains and provide runoff estimates. However, because of the size of the Mina Corridor, no region-wide comprehensive floodplain analysis has been conducted to delineate the 100- and 500-year floodplains for all the drainages in the area. A rise in the surface elevation of any standing water on a dry lake bed creates a potential flood hazard where the MRC is located adjacent to dry lake beds. The following dry lake beds along the rail route from Yucca Mountain to Wabuska, Nevada, collect and dissipate runoff from their respective hydrographic basins: Mason Valley, Sunshine Flat, Campbell Valley, Walker Lake, Soda Spring Valley (Rhodes Salt Marsh), Columbus Salt Marsh, Big Smoky Valley, Clayton Valley, Stonewall Flats, Alkali Lake, Alkali Flat, Sarcobatus Flat, Oasis Valley, and Crater Flat.

Many washes and arroyos pose a potential flood hazard to the proposed rail route. In the northwest, Weber Reservoir and Walker Lake are the major surface water impoundments. Also in the northwestern portion of the region, Walker River drains the northwestern hydrographic areas to the north, then east and finally south. In the southern part of the region, the Amargosa River and Beatty Wash drain the Upper Amargosa Valley to the north and northeast. Big Wash intersects the MN2 alignment south of Tonopah. Several small and shallow reservoirs are located in the central part of the alignment. Near Yucca Mountain, Forty Mile Canyon originates on Pahute Mesa and intersects the Amargosa arroyo in the Amargosa Desert. The Amargosa arroyo continues to Death Valley, California (ERDA, 1977).

A typical example of the MRC watershed hydrology can be represented by the conditions observed in the southern part of the MRC near Yucca Mountain. In this location, the

Amargosa River system drains Yucca Mountain and the surrounding areas. Although referred to as a river, the Amargosa and its tributaries (the washes that drain to it) are dry along most of their lengths most of the time. Exceptions include short reaches where groundwater discharges to or converges with the channel; examples are near Beatty, Nevada; south of Tecopa, California; and in southern Death Valley, California.

No perennial streams or natural bodies of water occur at the Yucca Mountain site or in the surrounding land area. In this region, most of the water from summer storms is lost relatively quickly to evapotranspiration unless a storm is intense enough to produce runoff or subsequent storms occur before the water is lost (CRWMS M&O, 2000). Evapotranspiration is lower during the winter, when water from precipitation or melting snow has a better chance to result in stream flow.

Thunderstorms in the area can be local and intense, creating runoff in one wash while an adjacent wash receives little or no rain. In rare cases, however, storm and runoff conditions can be extensive enough to result in flow being present throughout the drainage systems. Glancy and Beck (1998, all) documented conditions during March 1995 and February 1998 where Forty Mile Wash and the Amargosa River flowed simultaneously through their primary channels to Death Valley. The 1995 event represents the first documented case of this flow condition and generated the higher recorded flows. The peak flow near the location where the existing Yucca Mountain access road crosses Forty Mile Wash was reported to be about 3,500 cfs (Glancy and Beck, 1998, p. 7). This flow is much less than that calculated as the 100-year flood event for Forty Mile Wash (as given in Table 5-1). The occurrence of flow in both Amargosa River and Forty Mile Wash, however, might be a more unusual event because it requires generation of runoff over a much larger area than either single drainage area and in the same timeframe.

Although flow in most washes is rare, the area is subject to flash flooding from intense summer thunderstorms or sustained winter precipitation. When it occurs, intense flooding can include mud and debris flows in addition to water runoff (Blanton 1992).

Table 5-1 lists peak discharges for estimated floods along the main washes at Yucca Mountain, including a value for the estimated regional maximum flood. In addition to the flood estimates listed in the table, DOE used another estimating method, the *probable maximum flood* methodology [based on American National Standards Institute and American Nuclear Society Standards for Nuclear Facilities (ANS 1992, all)] to generate maximum flood values for washes adjacent to the existing facilities and operations at the North and South Portals. The flood value this method generates, which includes a bulking factor to account for mud and debris (including boulder-size materials), is the most severe reasonably possible event for the location under evaluation and is larger than the regional maximum flood listed in Table 5-1. DOE used the probable maximum flood values to predict the areal extent of flooding and to determine if facilities and operations are at risk of flood damage.

Table 5-1: Estimated Peak Discharge along Washes at Yucca Mountain[a]

Name	Drainage area (sq mi)	Peak discharge 100-yr flood (cfs)	Peak discharge 500-yr flood (cfs)	Regional Maximum flood (cfs)
Forty Mile Wash	313	12,000	56,800	530,000
Busted Butte (Dune) Wash	6.6	1,400	6,400	42,000
Drill Hole Wash	15	2,300	9,900	85,000
Yucca Wash	17	2,400	12,000	92,000

a. Source: Squires & Young (1984. p. 2) converted to U.S. customary units.

b. Includes Midway Valley and South Portal Washes as tributaries, north and south portal areas.

The U.S. Geological Survey published a methodology for calculating peak flood discharges in the southwestern United States (USGS, 1994). A preliminary evaluation indicates that the methodology could result in estimates of 100-year floods that are larger than those listed in Table 5-1.

Potential hydrologic hazards along the rail corridors include flash floods and debris flow. All alignment alternatives studied have the potential flash flooding concerns.

Some flood zones along the potential rail corridors and their associated alternate segments have been identified through the use of Flood Insurance Rate Maps and Floodway Maps published by FEMA. Although limited in coverage, where available, the maps do provide an indication of 100-year flood zones that might exist along the rail corridors.

5.5.2 MRC Watershed Descriptions

The Mina Rail Corridor crosses two (2) USGS Hydrographic Regions (Region 16: Great Basin Region; Region 18: California Region), and eight (8) Hydrologic Unit Code (HUC) Basins listed in Table 5-2. Figures 5-1 and 5-2 illustrate the entire tributary watershed area of approximately 8,353 square miles that will affect the rail route drainage design. For analysis purposes, the tributary watershed area was divided into smaller sub-watersheds given in Table 5-3 and shown on Figure 5-2. Each of the sub-watersheds will be treated as separate modeling units. The watersheds are cross-referenced by rail segment in Table 5-4.

For the MRC Study, a software program was customized to analyze stream networks for the purpose of dividing the large HUC basins into smaller sub-watersheds. However, it should be noted that sub-dividing the HUCs was not authorized until after the *Hydrologic and Drainage Evaluations Report Caliente Rail Corridor Hydrologic Analyses* (CRC Report) was published June 27, 2005. As such, the best available information was used to identify sub-watershed areas tributary to the rail segments described in the CRC Report. The sub-watersheds or "Hydrographic Areas" referenced in the CRC Report (CRC, Table 5-3) are based on Administrative Groundwater Basins (AGB) published by the State of Nevada's Department of Conservation and Natural Resources, Office of the State Engineer, Division of Water Resources (January 2001). As a cross reference between the two corridor studies, the sub-divided HUC basin names are provided for all rail segment descriptions in this report, and AGB numbers are included for those segments that are common between the two corridor alignments: GF4, CS4, BC2, BC3, CS5, OV1, OV3, CS6, BW1, and CS7.

Table 5-2: MRC Watersheds

USGS HUC Basin Name	**Sq. Mi.**
Cactus-Sarcobatus Flats	1,726.34
Fish Lake – Soda Spring Valleys	967.70
Gabbs Valley	227.08
Ralston-Stone Cabin Valleys	880.07
Southern Big Smoky Valley	2,049.60
Upper Amargosa	774.49
Walker	1,017.82
Walker Lake	712.96
Total =>	**8,356.06**

Table 5-3: Subwatersheds along the MRC by Watershed Name

Sub-unit Name	**Sq. Mi.**
Cactus-Sarcobatus Flats – Alkali Flat	445.32
Cactus-Sarcobatus Flats – Central	155.89
Cactus-Sarcobatus Flats – Stonewall Flat	383.31
Cactus-Sarcobatus Flats – Tolicha Wash	223.74
Cactus-Sarcobatus Flats – Jackson Wash	518.08
Fish Lake – Soda Spring Valleys – Columbus Marsh	384.67
Fish Lake – Soda Spring Valleys – Rhodes Marsh	204.35
Fish Lake – Soda Spring Valleys – Soda Spring	378.68
Gabbs Valley – Rawhide Flats	227.08
Ralston-Stone Cabin Valleys – Big Wash	322.34
Ralston-Stone Cabin Valleys – Clayton Valley	557.73
Southern Big Smoky Valley	2,049.60
Upper Amargosa – Amargosa Wash	281.26
Upper Amargosa – Beatty Wash	87.33
Upper Amargosa – Forty Mile Wash	405.90
Walker	1,017.82
Walker Lake – Corey Creek	282.19
Walker Lake – North	312.06
Walker Lake – Ryan Canyon	118.71
Total =>	**8,356.06**

Table 5-4: Drainage System along the MRC by Rail Segment

Rail Segment	Hydrologic Unit Code Sub-Unit Name	Approx # of Drainage Crossings	Approx Rail Section Length (miles)
MSC0	Walker	4	5.3
S1/S4	Walker	5	9.1
S1	Walker	5	18.3
S4	Walker	2	11.2
S5/S6	Walker, Gabbs Valley	9	14.7
S5	Walker, Gabbs Valley	6	9.2
S6	Walker, Gabbs Valley	12	16.2
S4/S5	Walker	8	6.4
S4/S5/S6	Walker	7	9.2
S1/S4/S5/S6	Walker	2	4.5
MCS1	Ryan Canyon, Soda Spring, Rhodes Marsh, Columbus Marsh, Southern Big Smoky Valley	72	72.2
MN1	Southern Big Smoky Valley, Clayton Valley, Big Wash	47	39.4
MN2/MN3	Southern Big Smoky Valley, Big Wash	30	45.3
MN3	Big Wash	21	9.1
MN2, MN2/GF4	Jackson Wash, Stonewall Flats, Big Wash	24	19.0
MN2/CS4	Jackson Wash	14	9.4
MN1/MN3	Jackson Wash, Clayton Wash, Big Wash	58	33.5
MCS2/CS4	Jackson Wash	1	2.2
BC2	Jackson Wash, Central, Tolicha Wash	34	12.5
BC3	Jackson Wash, Central, Tolicha Wash	24	12.3
CS5	Tolicha Wash, Alkali Flat, Amargosa Wash	88	24.9
CV1	Amargosa Wash	25	6.1
CV3	Amargosa Wash	33	8.2
CS6	Beatty Wash, Forty Mile Wash, Amargosa Wash	24	31.8

Note: Drainage crossings mostly from 1:24,000 quad indicated flow lines. Also included are locations where significant crossings are probable based on prominent flow path contours or features.

The following presents a description of the watershed areas along each of the rail segments. Drainage areas are not additive for the rail segments because some of the alternative segments share portions of their drainage areas.

Segment MCS0 – Existing

The northern-most segment of the Mina Rail Corridor begins about three miles east of US 95 Alternate Route and the town of Wabuska on the existing Union Pacific Railroad. Since the railroad is already constructed, additional drainage crossings are not anticipated along this 5.3-mile reach within the Walker HUC. Four mapped drainage ways cross the existing Union Pacific rail line in Segment MCS0, including the Walker River. Drainage patterns flow from south to north along Segment MCS0.

Segment S1/S4

The S1/S4 alternative is proposed new construction that will connect to Segment MCS0. Segment S1/S4 continues east for approximately six miles of its 9.1-mile length and then turns south into Sunshine Flat generally paralleling the Walker River. Segment S1/S4 is on the Walker River Paiute Reservation for most of its length.

Segment S1/S4 is entirely within the Walker HUC, which has a total drainage area of about 1,020 square miles. Topography of the Walker watershed ranges in elevation from approximately 4,200 feet to 6,700 feet above mean sea level. The Walker River was flowing north when it crossed Segment MCS0, but it's flowing south where it crosses Segment S1/S4 about two miles from the segment beginning. Drainage patterns within the Walker HUC will impact Segment S1/S4 from the north along its east-west alignment and from the east when it turns south. There are five identifiable drainage crossings (arroyo, wash, or river) along Segment S1/S4, including the Walker River. The Walker River crossing will require a drainage structure with a minimum clearance height (to bridge low chord or culvert rise) of 10 feet.

Segment S1

The S1 alternative splits from the S1/S4 combined alignment and continues south and southeast for about 18.3 miles. The first five miles of the alignment parallels the east side of Weber Reservoir. About one mile due south of Weber Dam, Segment S1 bends southeast and runs along the south edge of the Calico Hills. At Double Springs, Segment S1 bends south again for the last couple miles of its length. Segment S1 is on the Walker River Paiute Reservation.

Segment S1 lies entirely within the Walker HUC, which has a total drainage area of about 1,020 square miles. Topography in the Walker watershed ranges in elevation from approximately 4,200 feet to 6,700 feet above mean sea level. Drainage will impact Segment S1 primarily from the north and east as runoff makes its way to the Walker River on the west side of the alignment. There are five identifiable drainage crossings along this rail segment.

Segment S4

The S4 alternative also splits from the S1/S4 combined alignment and continues south and east for about 11.2 miles. The first three miles of the alignment are similar to S1, but Segment S4 bends east before the south end of Weber Reservoir. This segment crosses north of the Calico Hills and then turns southeast into Long Valley. Segment S4 is on the Walker River Paiute Reservation.

Segment S4 lies entirely within the Walker HUC, which has a total drainage area of about 1,020 square miles. Topography in the Walker watershed ranges in elevation from approximately 4,200 feet to 6,700 feet above mean sea level. Drainage will impact Segment S4 primarily from the north and east as runoff makes its way toward Weber Reservoir. There are two identifiable drainage crossings along this rail segment, however, the alignment also parallels a tributary draining into Weber Reservoir for about six miles. Depending on the sinuosity of the tributary and actual location of Segment S4, additional crossing structures may be required.

Segment S5/S6

The northernmost portions of Alternatives S5 and S6, which also connect to Segment MCS0, take a more northeasterly route after crossing the Walker River. The S5/S6 alternative is proposed new construction that generally proceeds east-northeast along the southern edge of the Desert Mountains for about 12 miles before bending southeast into Long Valley where S5 and S6 diverge. Segment S5/S6 is almost entirely within the Walker River Paiute Reservation.

The roughly 15-mile segment begins in the Walker HUC and then enters the Gabbs Valley HUC for the last three miles of its length. The two HUCs have a total drainage area of about 1,245 square miles and similar topography with elevations ranging from approximately 4,200 feet to 6,700 feet above mean sea level. The Walker River was flowing north when it crossed Segment MCS0, but its flowing south where it crosses Segment S5/S6 about two miles from the segment beginning. Flow directions in the Walker HUC are from north to south, and from northeast to southwest in the Gabbs Valley HUC along this reach of the rail alignment. There are nine identifiable drainage crossings along Segment S5/S6, including the Walker River. The Walker River crossing will require a drainage structure with a minimum clearance height (to bridge low chord or culvert rise) of 10 feet.

Segment S5

The S5 alternative splits from the S5/S6 combined alignment and continues south-southeast for about nine miles. The entire reach is in Long Valley where it crosses the Lyon County / Mineral County boundary. Segment S5 is on the Walker River Paiute Reservation.

Segment S5 begins in the Gabbs Valley HUC and then enters the Walker HUC for the majority of its length. The two HUCs have a total drainage area of about 1,245 square miles and similar topography with elevations ranging from approximately 4,200 feet to 6,700 feet above mean sea level. There are six identifiable drainage crossings along this rail segment and, because the alignment is in a valley, flow approaches from both west and east directions.

Segment S6

The S6 alternative also splits from the S5/S6 combined alignment, but heads in a more southeasterly direction within Long Valley. When it reaches US 95, Segment S6 bends northeast and parallels the highway for a short distance to cross the Terrill Mountains. The alignment then bends southeast again and runs along the east side of the Terrill Mountains for about 11 miles. The 16.2-mile long S6 alternative is on the Walker River Paiute Reservation.

Segment S6 is primarily within the Gabbs Valley HUC and then enters the Walker HUC the last three miles of its length. The two HUCs have a total drainage area of about 1,245 square miles and similar topography with elevations ranging from approximately 4,200 feet to 6,700 feet above mean sea level. There are 12 identifiable drainage crossings along this rail segment. Within Long Valley, drainage patterns flow east toward the rail alignment, but when the alignment is east of the Terrill Mountains, drainage comes from the west.

Segment S4/S5

Segment S4/S5 is a continuation of the S4 and S5 alternatives described above. Segment S4/S5 begins in a southeasterly direction and then turns east for the majority of its approximately 6.4-mile length. The S4/S5 alignment passes along the south side of the Terrill Mountains and then bends southeast again at its terminus. Segment S4/S5 is on the Walker River Paiute Reservation.

Segment S4/S5 lies entirely within the Walker HUC, which has a total drainage area of about 1,020 square miles. Topography in the Walker watershed ranges in elevation from approximately 4,200 feet to 6,700 feet above mean sea level. Drainage will impact Segment S4/S5 primarily from the north as runoff drains off the Terrill Mountains toward the south. There are eight identifiable drainage crossings along this rail segment.

Segment S4/S5/S6

Segment S4/S5/S6 connects the S4/S5 and S6 alternatives, and continues as a combined route in a southeasterly direction for about three miles. Upon reaching an old railroad grade, Segment S4/S5/S6 bends southwest and passes on the north side of the Agai Pah Hills for the remaining 6.5 miles of its length. Segment S4/S5/S6 is on the Walker River Paiute Reservation.

Segment S4/S5/S6 lies entirely within the Walker HUC, which has a total drainage area of about 1,020 square miles. Topography in the Walker watershed ranges in elevation from approximately 4,200 feet to 6,700 feet above mean sea level. Drainage will impact Segment S4/S5/S6 primarily from the south as runoff drains off the Agai Pah Hills toward the dry lake beds to the north. Segment S4/S5/S6 passes along the east side of the dry lake beds in the northern part of the alignment. There are seven identifiable drainage crossings along this rail segment.

Segment S1/S4/S5/S6

Segment S1/S4/S5/S6 combines the S1 and S4/S5/S6 alternatives and continues as a combined route in a southerly direction for about 4.5 miles. The segment passes along the west side of the Agai Pah Hills and connects to the existing Department of Defense rail line heading south on the east side of Walker Lake. Segment S1/S4/S5/S6 is on the Walker River Paiute Reservation.

Segment S1/S4/S5/S6 lies entirely within the Walker HUC, which has a total drainage area of about 1,020 square miles. Topography in the Walker watershed ranges in elevation from approximately 4,200 feet to 6,700 feet above mean sea level. Drainage will impact Segment S1/S4/S5/S6 primarily from the east as runoff drains off the Agai Pah Hills toward Walker River. There are two identifiable drainage crossings along this rail segment.

Segment MCS1 – Existing DOD Line

Approximately 21 miles of the existing Department of Defense (DOD) rail line connects new construction Segments S1/S4/S5/S6 and MCS1 described below. Since the railroad is already constructed, further study was not performed for this reach of rail line.

Segment MCS1

Segment MCS1 begins at the existing DOD rail line east of the Hawthorne Ammunition Depot. The 72.2-mile long segment roughly parallels US 95 and crosses through the Walker – Ryan Canyon sub-unit and Fish Lake-Soda Spring Valleys HUC. These drainage areas total about 1,090 square miles. The southern end of the segment enters into the southwest corner of the Southern Big Smoky Valley HUC as well. MCS1 goes through Soda Spring Valley and crosses State Highway 361 north of Luning. It continues to parallel US 95 until crossing the highway and ends at Blair Junction.

Flow directions trend from the east side of the segment with the possibility of flooding due to the additional contributing areas to the west of the valleys. There are 72 identifiable drainage crossings along this rail segment.

Segment MN1

Segment MN1 begins in the Southern Big Smoky Valley HUC and runs through the Clayton Valley and Big Wash sub-basins of the Ralston-Stone Canyon Valleys HUC. These drainage areas total over 2,900 square miles with elevations ranging from approximately 4,270 feet to 10,190 feet above mean sea level.

Segment MN1 skirts a series of dry lake beds. Runoff impacting the alignment will be primarily from the west; however, larger areas contribute from the east to the dry lake beds and ponding may be a concern.

There are 47 identifiable drainage crossings along this rail segment. The 39.4-mile rail segment runs south of Blair Junction into the town of Silver Peak and turns northeast toward Alkali. Before reaching Alkali, it turns south toward the Montezuma Range.

Segment MN2/MN3

The MN2/MN3 alternative turns east from the MCS1 terminus and generally parallels US 6 along an old railroad grade toward Tonopah. About 12 miles west of Tonopah, the alignment bends south, again following the old railroad grade, and passes through the Klondike Site. Just south of Klondike Site, Segment MN2/MN3 nears US 95 and ends about 7.5 miles north of the town of Goldfield.

Segment MN2/MN3 begins in the Southern Big Smoky Valley HUC and runs through the Big Wash sub-basin of the Ralston-Stone Canyon Valleys HUC. These drainage areas total almost 2,400 square miles with elevations ranging from approximately 4,270 feet to 10,190 feet above mean sea level.

Segment MN2/MN3 crosses several dry lake beds south of US 6. Runoff impacting the majority of the alignment will be primarily from the west; however, larger areas contribute runoff from the north and east to the dry lake beds where ponding may be a concern. There are 30 identifiable drainage crossings along this 45.3-mile rail segment.

Segment MN3

Segment MN3 connects Segments MN1 and MN2/MN3 at their southern ends. The MN3 alignment runs in an east-west direction south of the town of Alkali for a distance of 9.1 miles. The segment lies entirely within the Big Wash sub-basin of the Ralston-Stone Cabin valleys HUC. The Big Wash sub-basin has a total drainage area of about 320 square miles.

Flow in washes impacting the MN3 alignment will be primarily from the south as runoff makes its way to Alkali Lake, a dry lake bed. There are 21 identifiable drainage crossings along this rail segment.

Segment MN2 and MN2/GF4

Segment MN2 begins at the junction of MN2/MN3 and MN3 a couple miles south of the Klondike Site. The segment parallels US 95 in a southerly direction for about five miles before becoming MN2/GF4. Segment GF4 is part of the Caliente Rail Corridor (CRC) alignment and is referenced here to link identical alignments between the two corridor studies. (Only a portion of the CRC GF4 alternative coincides with the MRC MN2 alignment.) Segment MN2/GF4 continues to parallel US 95 and passes on the west side of Goldfield before turning east. The segment winds through various passes and valleys in a predominantly southerly direction to the Ralston Site.

Segments MN2 and MN2/GF4 pass through the Stonewall Flat and Jackson Wash sub-basins of the Cactus-Sarcobatus Flats HUC, and the Big Wash sub-basin of the Ralston-Stone Cabin Valleys HUC. These drainage areas total over 1,200 square miles with elevations ranging from approximately 5,050 feet to 8,300 feet above mean sea level. (In the CRC Report, Hydrographic Areas (AGB) 141, 142, 144, and 145 were listed for Segment GF4 of which all but 141 are still common to Segment MN2/GF4. Since only a portion of CRC Segment GF4 is common to the MRC alignment, watershed areas and characteristics will differ slightly from that described for the entire segment in the CRC Report.)

Flow in washes impacting the MN2 and MN2/GF4 alignment will be primarily from the east; however, the alignment does pass by dry lake beds with runoff draining into the lakes from the west. There are 24 identifiable drainage crossings along this 19.0-mile rail segment.

Segment MN2/CS4

Segment MN2/CS4 continues south from Segment MN2/GF4 for another 9.4 miles toward Lida Junction along the east side of US 95. The alignment passes Stonewall Flat on the north and west side generally paralleling an old railroad grade. Segment CS4 is part of the CRC alignment and is referenced here to link identical alignments between the two corridor studies. (Only a portion of the CRC CS4 alternative coincides with the MRC MN2 alignment.)

Segment MN2/CS4 is entirely within the Jackson Wash sub-basin of the Ralston-Stone Cabin Valleys HUC with a drainage area of about 520 square miles. Elevations within this sub-basin range from approximately 4,690 feet to 7,880 feet above mean sea level. (In the CRC Report, Hydrographic Areas (AGB) 144 and 145 were listed for Segment CS4, which are still common to Segment MN2/CS4. Since only a portion of CRC Segment CS4 is common to the MRC MN2 alignment, watershed areas and characteristics will differ slightly from that described for the entire segment in the CRC Report.)

Flow in washes impacting the MN2/CS4 alignment will be primarily from the east and south toward the dry lake bed. There are 14 identifiable drainage crossings along this rail segment.

Segment MN1/MN3

Segment MN1/MN3 begins at the junction of MN1 and MN3 southwest of the town of Alkali. The segment trends in a southerly direction west of the Montezuma Range and then turns east across the range toward US 95. Before reaching US 95, the alignment bends south for several miles before turning east again north of the Cuprite Hills. Segment MN1/MN3 crosses US 95 and then turns south and parallels the highway where it ends at the same terminus as Segment MN2/CS4 east of Lida Junction.

Segment MN1/MN3 crosses Jackson Wash in the sub-basin of the same name, in addition to the Clayton Wash and Big Wash sub-basins of the Ralston-Stone Cabin Valleys HUC. These drainage areas total 880 square miles with elevations ranging from approximately 4,400 feet to approximately 8,300 feet above mean sea level.

Flow in washes impacting the MN1/MN3 alignment will be from the south and east along the north portion of the segment, and then from the west and north along the southern reach. There are 58 identifiable drainage crossings along this 33.5-mile rail segment.

Segment MCS2/CS4

Segment MCS2/CS4 starts where the MN2/CS4 and MN1/MN3 segments end west of Lida Junction and follows an old railroad grade for its 2.2-mile length. At the southern reach of the alignment, Segment MCS2/CS4 is east of smaller dry lake beds called Alkali Flat about 2.5 miles south of Lida Junction. Segment CS4 is part of the CRC alignment and is referenced here to link identical alignments between the two corridor studies. Only a portion of the CRC CS4 alternative coincides with the MRC MCS2 alignment.

The segment is within the Ralston-Stone Cabin Valleys – Jackson Wash sub-basin, which has a total drainage area of almost 520 square miles. Elevations within this sub-basin range from approximately 4,690 feet to 7,880 feet above mean sea level. In the CRC Report, Segment CS4 is within Hydrographic Areas (AGB) 144 and 145, of which 144 is common to Segment MCS2/CS4. Since only a portion of CRC Segment CS4 is common to the MRC MN2 alignment, watershed areas and characteristics will differ slightly from that described for the entire segment in the CRC Report.

Runoff impacting this reach of the rail line drains from east to west as it flows from the Stonewall Mountains to Alkali Flats. There is one identifiable drainage crossing along this rail segment.

Segment BC2

Segment BC2 is common to both the CRC and MRC alignments. Beginning at the terminus of MCS2/CS4, Segment BC2 continues south-southeast along the west perimeter of the Nevada Test and Training Range and ends near Scottys Junction. The 12.5-mile segment crosses through the Jackson Wash, Central, and Tolicha Wash sub-basins of the Cactus-Sarcobatus Flats HUC. These drainage areas total almost 900 square miles, of which 672 square miles is estimated to be tributary to Segment BC2. Elevations in the watershed range from approximately 4,125 feet to 9,040 feet above mean sea level. In the CRC Report, Segment BC2 is within Hydrographic Areas (AGB) 144 and a portion of 146.

Runoff impacting the segment will be primarily from the east off of Stonewall Mountain and the Pahute Mesa eventually draining to Sarcobatus Flats farther south of the BC2 terminus. This segment also parallels a few washes along the west side of Pahute Mesa. Segment BC2 crosses 34 identifiable drainage paths; however, the majority of these crossings are alluvial in nature and will likely migrate during storm events.

Segment BC3

Segment BC3 is common to both the CRC and MRC alignments. Segment BC3 begins and ends at the same location as BC2, but is a little farther west although it remains on the east side of US 95 for its 12.3-mile length. The segment passes through the Jackson Wash, Central, and Tolicha Wash sub-basins of the Cactus-Sarcobatus Flats HUC. These drainage areas total almost 900 square miles, of which 683 square miles is estimated to be tributary to Segment BC3. Elevations in the watersheds range from approximately 4,125 feet to 9,040 feet above mean sea level. In the CRC Report, Segment BC3 is within Hydrographic Areas (AGB) 144 and a portion of 146.

As with Segment BC2, runoff impacting the segment will be primarily from the east off of Stonewall Mountain and the Pahute Mesa eventually draining to Sarcobatus Flats farther south of the BC3 terminus. Segment BC3 crosses 24 identifiable drainage paths; however, the majority of these crossings are alluvial in nature and will likely migrate during storm events.

Segment CS5

Segment CS5 is common to both the CRC and MRC alignments. Segment CS5 starts at the BC2 and BC3 termini just northeast of Scottys Junction and continues south paralleling US 95 for 24.9 miles and ends about three miles north of the site of Springdale. Along this segment, the alignment crosses Tolicha Wash within the sub-basin of the same name in addition to passing through the Alkali Flat sub-basin of the Cactus-Sarcobatus Flats HUC. The segment also enters the Upper Amargosa – Amargosa Wash sub-basin at the southern end. These drainage areas total 950 square miles, of which 228 square miles is estimated to be tributary to Segment CS5. Elevations in the watersheds range from approximately 3,990 feet to 6,900 feet above mean sea level. In the CRC Report, Segment CS5 is within Hydrographic Areas (AGB) 146 and a portion of 228.

Runoff impacting the alignment will drain primarily from the east and most of the washes cross perpendicular to the rail alignment. Segment CS5 crosses 88 identifiable drainage paths, the majority of which appear to end at Sarcobatus Flats. In this area, the washes are alluvial in nature and will likely migrate during storm events.

Segment OV1

Segment OV1 is common to both the CRC and MRC alignments. Segment OV1 begins about three miles north of the site of Springdale and runs south-south east for 6.1 miles. Within the Oasis Valley, Segment OV1 crosses the Amargosa River, an ephemeral stream with its headwaters in Thirsty Canyon. The entire segment is within the Upper Amargosa – Amargosa Wash sub-basin, which covers 280 square miles and has elevations ranging from approximately 3,870 feet to 7,450 feet above mean sea level. It is estimated that 279 square miles drains toward Segment OV1. In the CRC Report, Segment OV1 is within a portion of Hydrographic Area 228.

Runoff impacting the alignment will drain primarily from the northeast toward the Amargosa River. Segment OV1 crosses 25 identifiable drainage paths. The alignment crosses most washes perpendicularly; however, it parallels one wash north of the Amargosa River. The railroad will likely require a drainage structure with a minimum clearance height (to bridge low chord or culvert rise) of 10 feet to cross the Amargosa River.

Segment OV3

Segment OV3 is common to both the CRC and MRC alignments. Segment OV3 begins at the same location as the OV1 alternative; however OV3 makes an exaggerated loop to the east of Segment OV1. Segment OV3 crosses the Amargosa River farther upstream in the Oasis Valley. The entire segment is within the Upper Amargosa – Amargosa Wash sub-basin, which covers 280 square miles and has elevations ranging from approximately 3,970 feet to 7,450 feet above mean sea level. It is estimated that 267 square miles drains toward Segment OV3. In the CRC Report, Segment OV3 is within a portion of Hydrographic Area 228.

Runoff impacting the alignment will drain primarily from the north and east toward the Oasis Valley and Amargosa River. Segment OV3 crosses 33 identifiable drainage paths along its 8.2-mile length, all of which are perpendicular to the alignment. The railroad will likely require a drainage structure with a minimum clearance height (to bridge low chord or culvert rise) of 10 feet to cross the Amargosa River.

Segment CS6

The MRC Segment CS6 is composed of CRC Segments CS6, BW1, and CS7 for a total length of 31.8 miles. Segment CS6 is the southernmost segment that runs southeasterly to the rail line terminus at the Yucca Mountain site. Segment CS6 crosses the Beatty Wash, Windy Wash, tributaries to Tates Wash, and many unnamed drainage ways. The entire segment is within the Upper Amargosa HUC, which covers an area of 775 square miles and has elevations ranging from approximately 3,840 feet to 7,440 feet above mean sea level. It is estimated that 172 square miles drain toward the MRC Segment CS6. In the CRC Report, Segments CS6, BW1, and CS7 are within portions of Hydrographic Areas 228, 229, and 227A. Refer to Figure 1-1 in the CRC Report for CRC segment limits.

Runoff impacting this segment will drain primarily from the east and north off Yucca Mountain, however, runoff will also drain into Crater Flat from the west off of Bare Mountain. The segment should be high enough on the Yucca Mountain alluvial fan to avoid impacts from runoff collecting in Crater Flat, which will eventually drain toward the Amargosa River to the southwest. Segment CS6 crosses 24 identifiable drainage paths including those named above. The majority of the washes cross the alignment perpendicularly; however, a few run parallel.

5.6 EXISTING DRAINAGE FACILITIES

Except where existing rail routes are to be utilized, no existing drainage facilities are known to exist along the corridor.

5.7 HYDROLOGIC HAZARDS

5.7.1 Floods

The MRC crosses approximately 420 identifiable washes between the beginning of the alignment in the Walker River Paiute Reservation to the Yucca Mountain Repository. Some of the major crossings include the Walker River, Jackson Wash, Tolicha Wash, Amargosa River, and Beatty Wash. Some crossings are in 100-year flood zones delineated by studies in areas the corridor passes through. A majority of the crossings may also be subject to threats of flash floods with mud or debris flow.

5.7.2 Alluvial Fans

Several of the areas along the MRC route cross over alluvial fans or at the toe of the fan. In either case, the risk to the MRC is from migrating flow paths on both active alluvial fans as well as the alluvial surfaces whose braided channels are limited in capacity to less than the 100-year flood event. In both cases, the direction of runoff across the fan is variable and therefore, will require either oversized drainage improvements under the MRC or on-fan improvements to direct and confine the 100-year flow path. In addition, erosion and sediment transport are potential hazards on alluvial fans.

Probable alluvial fan crossings include:

- Soda Spring Valley, Rhodes Marsh, and Columbus Marsh
  Segment MCS1 crosses a number of fans along US 95.

- Southern Big Smoky Valley
  Segments MN1 and MN2 are crossed by a number of alluvial fans, including Jackson Wash and Big Wash.

- Tolicha Wash
  Segment CS5 crosses the Tolicha Wash fan located northeast of Sarcobatus Flat as well as other unnamed fans.

Additional alluvial fans areas may be identified during the detailed hydrologic modeling phase of this project.

5.7.3 Mud and Debris Flows

Mud and debris flow risks exist throughout the MRC where existing drainageway slopes are sufficiently steep to increase flow velocities to initiate displacement and transport toward the MRC. This risk is minimized in locations where the MRC is located at a distance greater than the expected runout distance of the mud and debris flow. The actual risk from mud and debris flow will be determined by location specific hydrologic and geotechnical analyses. Analyses will be completed with the hydrologic modeling phase of this project.

5.7.4 Dry Lake Beds

Several of the watershed areas are closed basins and as such, runoff from the arroyos and washes collect in dry lake beds where water evaporates or infiltrates over time. Other areas also have dry lake beds which, when filled, have outflow points. Dry lake beds, whether in closed basins or not, are a concern when the 100-year flood stage of the lake may inundate the railroad or its embankment, or saturate the underlying soils. Additionally, fine silts will be prevalent in the dry lake beds. As a minimum, the MRC should be located such that the railroad may be routed around the area affected by lake flooding.

Locations of dry lakes are identified in the description of the specific rail segments in Section 5.5.2.

5.7.5 Reservoirs

There are some reservoirs located within the MRC watersheds including Walker Lake, Weber Reservoir, Millers Pond, and a number other containments along the alignment. These reservoirs can create additional hydrologic hazards to the MRC if they breach. The extent of the hazard to the MRC is dependent on the increase in peak flow caused by the breach at the MRC and upon the hazard design of the individual reservoirs. Some of the reservoirs may reduce flood hazards to the MRC if they are designed and maintained to provide flood control benefits. A complete listing of the dams/reservoirs in the watershed is available on the following website: http://water.nv.gov/Engineering/Dams/Dam_Query.cfm

5.7.6 Wetlands

The area near the north end of the alignment around Yerington and Walker Lake is characterized by a number of standing water or wetland type areas (see Figure 3-6). These areas differ from the dry lake beds in that they typically contain water most of the year. Segments S1, S4, S5, and S6 are impacted by some of these areas. PBS&J performed a detailed analysis of the wetlands within an eighth of a mile on each side of the MRC. Please refer to the Waters of the U.S. Jurisdictional Determination Report for Yucca Mountain Project – Mina Rail Corridor, Task 1.1a, Information on Wetlands and Floodplains, last revised April 12, 2007.

5.7.7 Erosion and Sedimentation

Erosion and sedimentation in a natural channel may become a hazard when the stream parallels near or crosses the railroad. Erosion and sedimentation is a hazard when the water surface of a flood event is increased over the elevation computed based upon a fixed-bed assumption. Erosion of channel banks caused by flood events can also undermine the railroad bed and facilities. Additionally, sediment loading affects the erosion capabilities of the stream, both in terms of ability to erode solid masses and pick up additional sediment from banks and bed. The extent of this potential problem will depend on the bank and bed materials, the velocity of the flood flow at specific locations, and the location of the MRC related to these features. Once the peak flood flows and velocities are determined, the risk to the MRC from erosion and sedimentation problems will be identified. Erosion and sedimentation effects at structures will be addressed as part of the design process for each individual structure.

6.0 HYDROLOGIC FIELD RECONNAISSANCE

6.1 INTRODUCTION

In order to accurately model the conditions that are present along the MRC, field reconnaissance was conducted to collect site data. Starting on September 11, 2006, multiple 2-man crews drove and hiked the MRC Alignment from outside the town of Yerrington to Yucca Mountain, for a total of approximately 436 linear miles, considering all the alternative alignments. Additionally, the crews surveyed the watersheds draining to the alignment, which consisted of approximately 8,100 square miles. Field work was completed by the late February 2007, with the entire watershed surveyed.

6.1.1 Purpose

Due to the size and variety of the area that will be modeled, detailed information is needed to form an accurate and reliable model. Existing information such as USGS maps and aerial photographs are not precise enough to use on their own. It was necessary to perform field investigations to determine the physical characteristics of the area being modeled as well as determine any areas of special significance. Data collected included hydrologic and hydraulic information, land use, land cover, and soil type. Areas of special interest include rivers, washes, reservoirs, and dry lakes.

6.1.2 Crews

Each crew member attended thorough training in safety procedures, defensive driving, and equipment use. The training lasted approximately three days and covered everything from CPR to the use of handheld Global Positioning System (GPS) equipment. Field crews consisted of two individuals to each vehicle, with as many as three sets of crews out in the field at all times. Crew members stayed in small towns along the alignment in order to expedite the data collection. According to safety regulations, crews checked in at least three times per day with Ranch Control (BSC) or the Nevada Point of Contact to inform everyone of their location. This was used to ensure short response time in the case of any emergencies. Grid Map locations or GPS positions were provided to determine the general location of the work taking place for the day.

6.1.3 Methods

Utilizing tablet PCs with a GPS receiver attached, and a digital camera that also contained a GPS receiver, data was collected in real time conditions. Data was collected with a series of Graphical User Interfaces (GUI) within the tablet PC. Geographic Information System (GIS) maps containing topography, watershed basins, and soil boundaries along with roads, wilderness areas, and national parks were loaded onto the tablet PC before entering the field. Using the GPS capabilities of the tablet PC, data such as wash locations and soil types were collected and placed on the maps at exact locations. Each data point was collected with a GPS stamp showing the location of the collector at the time the information was gathered. Additionally, each data point was accompanied by photographs of the surrounding area. These photographs were also stamped with GPS coordinates. This allowed for the photographs to be hyper-linked directly to the GIS maps for later review.

6.2 DATA

6.2.1 Hydrologic Data

Watershed boundaries were roughly determined using a watershed delineation program that defined the basin boundaries for the area. These smaller basins make up the larger Hydrologic Unit Code (HUC) described in Section 5. The basin boundaries were then confirmed in the field for accuracy using the tablet PC. Confirmed basins can be used directly in the model while basins that were not confirmed can be modified to more accurately reflect the conditions in the field.

6.2.2 Hydraulic Data

For each basin that was delineated by the watershed program, a wash point was recorded on the tablet PC. The wash points included descriptions for channel type, bottom width, depth, side slope, wash composition and erosion potential as well as the exact location of the wash. This information will be used to determine velocity and lag times for each basin. At least one wash point was collected for each basin, while every wash was collected in basins that directly impact the rail alignment. The basins that directly impact the rail alignment will be broken down into smaller basins to more accurately determine the flowrate at each potential wash crossing.

6.2.3 Vegetation and Land Use

To accurately determine the runoff rates for each basin, it was essential to accurately describe the vegetation and land use in each area. Vegetation varied from small desert sage brush with only 5% total ground cover to Mesquite and Juniper tree cover with high desert grasses covering up to 50% of the ground. Land use ranged from no use to cattle grazing and agriculture. Individual areas were delineated directly onto the GIS maps using the tablet PC by creating polygons that could be edited with the required land use and vegetation cover. (The collected data is included on the Hydrologic Data DVD for this report.)

6.2.4 Soil Type

Soil type is the final requirement for calculating runoff values from a given basin. Hydrologic Soil Groups range from A, low runoff potential, to D, high runoff potential, with B and C in between. NRCS Soil maps were overlaid on the MRC watershed and this information along with the data collected in the field will be used to determine the peak runoff rates that impact the MRC.

7.0 WATERSHED ANALYSIS PLAN FOR PHASE 2

7.1 INTRODUCTION

The watershed analysis plan presents the methods and procedures to be utilized to generate the peak runoff rates and volumes needed for drainage facility design as well as information on other flood hazards such that measures to mitigate these hazards can be analyzed and designed. The Watershed Analysis Plan is divided into two sections. The first section presents the criteria to be used for analysis of flood flows and flood hazards. The second section presents the proposed watershed analysis scope (work tasks) needed to complete the watershed analysis portion of the work.

7.2 WATERSHED RUNOFF DETERMINATION CRITERIA

7.2.1 Introduction

Hydrologists rely on precipitation data, stream gage data, and historic evidence of flood events to predict peak stream flows for various frequencies of runoff events. Many areas of the United States have over 50 years of frequently occurring precipitation and flood events upon which to make accurate statistical estimates of future peak flow occurrences. However, in the state of Nevada, the accuracy of said estimates is severely hampered by many factors including:

a) Sparsely located rainfall gages: There are few (six) rainfall gages located within the MRC watersheds with over 30 years of records, however, some record only daily (24 hour) rainfall data.

b) Sparsely located stream flow gages. Within the MRC drainage areas, there are five stream gage stations, however, they do not have sufficiently correlated records upon which regression equations have been formulated (USGS, 1994).

c) Sparse storm events. Most of the study area receives less than 10 inches of precipitation per year. Much of this precipitation occurs during the winter months as snow or low intensity rainfall. During the summer months, many areas experience only one or two thunderstorm events per year. This results in many streamflow gages recording no flow for the entire year.

Analysis for determination of peak runoff flow rates necessitates the use of various methods to provide the most accurate estimate of the peak flow events. For this project, statistical analysis, regional regression analysis, and synthetic rainfall/runoff modeling will all be used and compared, where available and applicable, to provide the necessary peak runoff values for design of the MRC facilities.

7.2.2 Runoff Determination Issues

7.2.2.1 Flood Frequency

Floods will be simulated for severe storm events; however, in arid regions severe storm frequency is not equivalent to flood frequency. Gage records in southern

Nevada often show numerous years with nearly zero stream flow. Smaller storms, even though severe, may produce little runoff. The frequency of storms needs to be adjusted to account for the conditional probability that runoff is near zero. For example, it may require a 120-year storm to produce a 100-year flood.

7.2.2.2 Reliability

All of the data for simulation of floods has measurement error. These errors are of two types: first, there is a gage error, which may include equipment malfunction or damage; and second, there is a spatial error, i.e., map accuracy. The main hydrologic modeling processes (precipitation, infiltration/storage, and surface runoff) have both types of errors. Sources of data provide estimates of parameter range and spatial accuracy, so such data should be explicitly incorporated into the model to develop confidence ranges. The limits of map accuracy should be adhered to in the modeling process.

7.2.2.3 Risk

The drainage design will address the risk of 100-year flooding to the rail route. For drainage structures that cross the route (culverts and bridges), the design will be evaluated based on the estimated 100-year flood peak and volume. The designer may consider the uncertainty of the flood estimate, site conditions, and other factors in the hydraulic analysis of the drainage structure.

The risk can also be affected by the configuration of the rail route. Rail routes that parallel streams are vulnerable to systematic failure. In a dynamic environment such as a river corridor, the width and depth of the channel can change dramatically in a major flood. This can result in the failure of one structure that leads to the failure of another downstream structure.

7.2.2.4 Model Testing

There are several choices for model testing. One method is a comparison of simulated model flood flows to the flow records at gage sites located within the corridor. The number of gages to test against could be increased by adding basins that are near the corridor to the modeling effort. Testing at gages can help to address the issue of arid region flood frequency and associated storm magnitude.

A general level of testing can be accomplished by comparison of modeling results to National Flood Frequency (NFF) regression equations and the associated statistics (i.e. confidence limits). Note that these regression equations are developed for small basins (less than 50 square miles) to mid-sized basins (less than 1,000 square miles) and may be too small for many of the MRC basins. The primary use of the NFF equations and statistics will be to evaluate model error, not to determine peak flow values

Finally, peak discharge envelope curves are available that can be used as a general test. The purpose of this comparison is to determine if model error is within general understood statistical limits.

7.2.2.5 Validation

Data sources that have been compiled into the simulation model format will be reviewed through the quality assurance process. This process will include tracking the originator of the data (the person responsible for compiling the source data into the model), an independent review of the data, and correction (this can be done by the originator). Each data source should be identified by a unique name and digest (a hash of the file that provides a unique finger print of the file). Other metadata should be provided with the file that, at a minimum, provides source map accuracy and parameter confidence limits.

7.2.3 Statistical Analysis

Statistical Analysis will be performed on records from the five stream flow gages within the MRC watersheds. Analysis will be performed in accordance with Bulletin 17B Methodology.

7.2.4 Regression Analysis

The USGS, 1994 regional regression equations provide the most current regional regression analysis available for watersheds covering the MRC. However, the lack of adequate data supporting this report within the MRC watersheds and the lack of inclusion of more recent data minimizes the reliability of estimations produced by this method.

7.2.5 Rainfall/Runoff Modeling

7.2.5.1 Modeling Classes

Today there are two distinct classes of hydrologic event simulation models: distributed process and lumped parameter. Distributed process models can simulate storm runoff at the USGS DEM scale of topographic mapping. This type of modeling facilitates the integration of other spatial data that is of a similar scale for soils and rainfall distribution. Distributed models are useful when runoff is not well confined or directed, such as on an alluvial fan. In arid regions, such areas are often accompanied by large transports of sediment, which also needs to be modeled.

Lumped parameter modeling is well suited to the modeling of organized basins with a hierarchy of tributaries. The scale of the sub-basins for lumped parameter modeling can be much larger, which reduces the amount of data to be managed. The analysis of large, well-organized basins at a few design points is best accomplished with a lumped parameter model. Lumped parameter models can be used to evaluate distributed conditions where the flow paths are better defined or uncertainty analysis can be used to evaluate multiple path options.

The hydrologic modeling of a transportation corridor requires the analysis of major stream crossings and streams that parallel the route. Between major crossings there will be smaller, inter-fluvial basins. These basins are typically smaller than the basins that would normally be delineated as a model sub-basin. If the area is less than about 10 acres then it should be combined with another sub-basin. Table 7-1 summarizes the previous discussion.

Table 7-1: Recommended Hydrologic Models

Class	Application	Element Scale Range
Distributed Process Model	1. Poorly confined flows 2. Large alluvial fan drainageways	0.25 to 10.0 acres
Lumped Parameter Model	1. Hierarchical watersheds 2. Confined diversions 3. Multi-path analysis with uncertainty	10 acres to 10 sq mi
Small basin analysis	1. Local corridor drainage facilities	Less than 40 acres

Most of MRC routes can be evaluated with lumped parameter modeling. Routes over alluvial fan terrain should initially be modeled using a multi-path approach based on uncertainty analysis. The multi-path analysis should consider the likely capacity of the drainageways with sediment deposition and channel avulsion.

Distributed process modeling should be applied to large, complex alluvial fans that affect a substantial segment of the route (over 1.0 mile). Such a crossing will involve multiple structures and overlapping risks to the route that can be more economically evaluated using a distributed model. The morphology of the fan should be reviewed for areas with the potential to avulse or change direction due to topographic conditions.

Small basins along the corridor will need to be delineated for the design of local drainage facilities (typically, small cross-culverts and rail-side ditches).

The four components of the hydrologic cycle that are important for a hydrologic simulation of a storm runoff are:

1. Precipitation
2. Infiltration and incidental storage
3. Surface runoff
4. Drainage network

Precipitation is very important for hydrologic engineering in regions where few measurements of floods have been made and the development of flood discharges must be accomplished by synthetic methods. Infiltration and shallow surface storage is the portion of the precipitation that enters the ground or evaporates and is not available for runoff. Some infiltration may return by way of groundwater to become stream flow, but generally is not an essential element in flood hydrology. Surface storage is water that is held in small puddles and small scale surface irregularities that ultimately infiltrates or evaporates. The drainage network consists of open channels, streams, and rivers that concentrate and convey surface runoff.

The density, gradient and shape of channels within the network greatly influence the movement of floods.

The patterns of the four dominant hydrologic elements are derived from various types of maps. As such, the various maps have the potential for error and inherent limits to accuracy.

7.3 RAINFALL/RUNOFF MODELING CRITERIA

The USACOE HEC-1 model will be utilized for modeling of the subject watersheds. The HEC-1 model will be coupled with a GIS pre-processor and post-processor to automate the generation of input data and output reports.

7.3.1 Model Protocol

7.3.1.1 Units

The project shall be conducted in United States customary units (CU). Table 7-2 gives the standard unit types that will be used for the project.

Table 7-2: Project Units

General Unit	Unit Type	Unit	Precision
Length	Structure Length	feet	To the nearest 10th
	Overland/Sheet Flow Length	feet	To the nearest ft
	Stream Branch Length	mile	To the nearest 1,000th
	Flow Depth	feet	To the nearest 10th
	Rainfall Depth	inch	To the nearest 100th
Rate	Infiltration Rate	inches per hour	To the nearest 100th
	Rainfall Rate	inches per hour	To the nearest 100th
	Flow Velocity	feet per second	To the nearest 10th
Area	Basin Area (small)	acre	Less than 160 acs
	Basin Area (large)	square mile	Greater than ¼ sq mi
Time	Hydrograph Duration	minutes	To the nearest minute
	Hyetograph Duration	minutes	To the nearest minute

7.3.1.2 Coordinate System

The large-scale basin mapping (watershed scale mapping) shall be derived from 1:24,000 scale topographic mapping obtained from the US Geological Survey. The topographic map shall be in the form of a DEM with a grid interval of 30 meter (98 feet). The horizontal datum shall be Universal Transverse Mercator (UTM) Zone 11 NAD 83 and the vertical datum shall be NAVD 88. The estimated spatial accuracy of this topographic mapping is given in Table 7-3. (Note: Since the UTM coordinate system is in metric, the primary table units are in meters.)

Table 7-3: Topographic Map Accuracy

Map Type	Scale	Radial Accuracy	Vertical Accuracy	Equivalent Contour Interval
Watershed Scale	1:24,000	14 m (45.6 ft)	1.85 m (6.1 ft)	6.1 m (20 ft)
Corridor Scale	1:6,000	3.4 m (11.0 ft)	0.46 m (1.5 ft)	1.5 m (5 ft)

Corridor-scale mapping shall be derived from 1:6,000 scale aerial-topographic surveys. The source data shall be mass points and feature lines with a horizontal datum in UTM Zone 11 NAD 83 and a vertical datum in NAVD 88. If the corridor mapping is prepared as a DEM, the grid interval should be no smaller than 7.5 meter (25 feet).

7.3.1.3 Topographic Models

The watershed-scale topographic surfaces shall be developed as DEM on a uniform grid of 10 meter (32 feet). Resolution of the DEM will not be sufficient to detect geomorphic features less than 200 meters (650 feet) as their primary dimension. This means that the watershed scale DEM should not be used within the corridor when it is necessary to evaluate detailed corridor features. However, the watershed scale topographic models are appropriate for evaluation of watershed runoff processes that pass through or along the corridor.

The corridor-scale topographic surfaces shall be developed as a triangulated irregular network (TIN) using surveyed mass points and breaklines. This model should have an approximate 200 meter (650 feet) buffer beyond the extents of the corridor survey that is composed of adjacent watershed-scale grid points. This will permit the corridor-scale topographic models to be overlapped with the watershed-scale models. The TIN models will be used for detailed hydrologic simulation within the corridor, such as hydrologic analysis of alluvial fans, stream flow routing, or stream scour and erosion at corridor crossings where detailed cross sections are needed.

DEM models at the corridor scale shall be the result of sampling of the corridor TIN models. Grid density shall not exceed the accuracy of the original mapping (7.5 meters or 25 feet). Likewise, depiction of contours for either the TIN or DEM models shall not exceed the accuracy of the topographic data source (see Table 7-3).

7.3.1.4 Precipitation Models

Precipitation
The precipitation models will be developed using the following procedure: 1) estimate point runoff and the associated confidence limits, 2) make a spatial distribution of the rainfall in accordance with the storm type (general or meso-scale), 3) determine locations for the storm center and direction of the storm pattern on the watershed, and 4) develop the temporal pattern and duration of the storm event.

Storm Frequency
Three storm frequencies will be analyzed for this project (see Table 7-4); the storm frequency that produces near zero flow, the 10-year storm, and the 100-year storm. The 10-year storm runoff will be compared to stream channel morphology (the bank full flow) [Leopold, Luna B., Water, Rivers and Creeks, 1997, University Science Books, Sausalito, California]. The 10-year storm runoff is used since more accurate estimates of 10-year runoff can be obtained from the stream flow gages than for the 100-year event. The near zero flow event will be used to confirm curve number (CN) estimates.

Table 7-4: MRC Hydrologic Study Flood Frequencies

Flood Probability	Study Use
P_{zero}	Storm frequency at near zero stream flow at a design point.
P_{10}	Indicator probability for fluvial morphology.
P_{100}	Design frequency for corridor drainage structures.

Adjustment for Near Zero Flows
Floods will be simulated from storm runoff; however, in arid regions severe storm frequency is not equivalent to flood frequency. This is because the frequent smaller storms may have zero runoff. The magnitude of larger storms needs to be adjusted to account for the conditional probability runoff that is near zero.

$$P' = (1 - P_z) \cdot P_s \qquad \text{(Equation 1)}$$

where: P' is the adjusted probability of a storm event,
P_s is the probability of the associated storm event, and
P_z is the probability of a storm event that produces near zero flow.

The adjustment factor will be determined from the analysis of gage records at stream gages near and within the corridor watersheds and simulation of storm runoff from these watersheds. Alternatively, a series of randomly generated rain events could be used to simulate an annual peak basin stream flow. The stream flows could be statistically analyzed to calculate frequency distribution statistics.

Equation 1 offers a direct adjustment to the input rainfall using the base configuration of a basin model. This is approximate and a more refined approach would be to derive synthetic flows from multiple runs. However, the latter approach would require variation of all the major hydrologic elements of each model and would need to presume conditional probabilities for each element. The latter may not lead to realistic results, since such conditional probabilities are uncertain and might largely be no more than educated guesses. The limitation of Equation 1 is that it assumes that the frequency distribution for storms and floods are directly related.

For watersheds less than 175 square miles in area, the average precipitation depth over the watershed will be used. The average depth will be computed by determining the point precipitation depth at the centroid of watershed and then reducing this value by a depth versus watershed area reduction relationship (see table 7.5).

Table 7-5: Precipitation Depth Reduction Factor versus Watershed Area

Watershed Area (square miles)	10	25	50	100	175
Reduction Factor	1.0	0.96	0.92	0.86	0.82

For watershed areas greater than 175 square miles, a storm pattern will be used over the watershed. The point precipitation depth will be estimated at the location of the center of the storm. The depth area reduction relationship and spatial pattern will produce nearly the same average rainfall for a watershed area of up to 175 square miles.

Precipitation Depth

NOAA Atlas 14 will be used to estimate the point precipitation values for a storm. This Atlas provides the most comprehensive and up-to-date analysis of rainfall data within the MRC watersheds. For basin areas less than 175 square miles, the point precipitation will be estimated at the centroid of the basin. For basins greater than 175 square miles in area, the precipitation will be estimated at the center of the storm pattern.

Where a spatial pattern of precipitation is used the precipitation depth for a sub-basin element will be computed from the weighted precipitation depths determined from the storm isopluvials.

Spatial Pattern

The spatial distribution of rainfall over a watershed will be represented by an elliptical pattern. The shape will be defined by a major axis that is 2.5 times the length of the minor axis. The initial isohyetal pattern for general and convective storms is given in the Table 7-6.

Table 7-6: Percent of Point Precipitation

Isohyetal Zone	Isohyetal Area (sq. miles)	Convective Storm	General Storm
A	10	100%	100%
B	25	93%	93%
C	50	87%	88%
D	100	81%	81%
E	175	75%	76%
F	300	58%	69%
G	450	45%	65%
H	700	36%	59%
I	1,000	30%	55%
J	1,500	22%	40%
K	2,150	17%	29%
L	3,000	13%	22%
M	4,500	8%	14%
N	6,500	3%	8%
O	10,000	0%	3%

Storm Size

The convective storm size is estimated to be 200 square miles and the general storm size is estimated to be 1,000 square miles. The fringe precipitation area for these storms extends beyond the nominal area of the storm size as can be seen by the precipitation pattern.

Orientation of the Storm

The primary orientation of convective storms is south to north (0 degrees as measured from north). The primary orientation of general storms is from southwest to northeast (45 degrees as measured from north).

Location of Storm Center

Initial centering of the storm center should coincide with the basin centroid. Additional trials shall be conducted to locate the storm center that gives the largest rainfall volume over the watershed and to locate the storm center that gives the largest peak flow at the design point.

Storm Tracking

The analysis of the effects of a storm tracking across a watershed is primarily used on larger watersheds where the aspect of the watershed parallels the typical storm track of the area under consideration. In Nevada, almost all of the major storm events typically track from west to east or southwest to northeast. However, the aspect of all the larger watersheds covering the MRC is generally from north to south. Thus, a fixed storm event will reasonably model the conditions expected in the MRC modeled watersheds.

Temporal Pattern
Appendix A.1 of the NOAA Atlas 14 will be used to develop the temporal distribution of severe precipitation.

Storm Duration
For thunderstorm events, a 24-hour rainfall event will be used with the peak precipitation occurring within the first hour of the storm event. The 24-hour event is suggested instead of a typical 3-hour or 6-hour thunderstorm event to provide better estimates of overall runoff volumes which may be needed for detention analysis (if and where applicable as a design solution).

7.3.1.5 Soils Model

Hydrologic soils data will be developed from the Nevada statewide soils map, subdivided into hydrologic soil types, and further verified with formal geotechnical investigations. Where geotechnical data conflicts with the hydrologic soils map produced, the map will be adjusted to reflect tested field conditions. Appropriate documentation of the reason for the change and the area/extent of the change will be provided.

The composite infiltration parameters will be determined by spatially weighting the values of parameter for each Hydrologic Soil Group within the sub-basin element.

7.3.1.6 Vegetation Model

Vegetative cover and land use data will be developed from the state-wide vegetative cover map and land use coverage from watershed area aerial photographs. This data has been reviewed with the collected field data. Where conflicts exist, the map will be adjusted to reflect field conditions with appropriate documentation of the reason for the change and the area/extent of the change.

7.3.1.7 Infiltration/Excess Precipitation Model

There are various methods, equations, and procedures available to determine the amount of precipitation that becomes surface runoff during a storm event as opposed to infiltration into the soil layers and surface extractions from vegetation and depressions. Most of these methods and equations attempt to relate the change over time in these infiltration and extractions depending on various parameters such as soil classification, soil depth, surface vegetation, and storm duration and intensity.

For the MRC watersheds, it is impractical to perform enough soil sampling within all the watersheds to obtain definitive soils characteristics. In contrast, there is sufficient reconnaissance level data available to generally characterize the soils, vegetation, and land use conditions of the subject watersheds.

A second important factor is the selected method's ability to mimic the historic and expected runoff conditions encountered in the subject watersheds. Existing data indicates that a significant portion of alluvial surface soils in Nevada either consist of surface rock features or buried caliche, which reduce the infiltration rates throughout the design storm event. Given the available data and the above described conditions, the Soil Conservation Service (SCS) CN method was selected as the most appropriate method for representing the rainfall/runoff conditions expected to occur within the MRC watersheds.

The SCS CN will be determined according to the hydrologic soils coverage in conjunction with the vegetative cover/land use map as matched to the CN description presented in the SCS TR-55 (USDA, 1986). The percent impervious option in HEC-1 will be utilized to represent the amount of rock outcrops and rock cover as well as other impervious surfaces that will generate immediate runoff upon application of precipitation. Antecedent moisture condition (AMC) II will be used for this project.

7.3.1.8 Drainage Network

Enumeration of Network Elements
The HEC-1 topology for a drainage network consists of branch elements and node elements. The node-branch labels shall encode the natural hierarchical structure of each watershed. A branch is defined by a seven character label in the following format: bbbhnnn, which indicates the basin number (bbb), the Horton order (h), and the branch enumeration (nnn). The node name in HEC-1 indicates a basic routing operation. The node is defined by a five character label in the following format: ffnnn, which indicates the operation type (ff) and the node enumeration (nnn).

7.3.1.9 Runoff Modeling

Unit Hydrograph Procedure
Several methods and designs are available for modeling the runoff response of watersheds to incremental rainfall patterns. For the subject watersheds, there is insufficient information on watershed responses to perform a detailed unit hydrograph shaping analysis. Thus, the SCS unit hydrograph, which is based upon unit response analyses across the United States, will be used for the runoff modeling of the MRC watersheds.

Estimates of Watershed Lag
The unit hydrograph procedure requires an estimate of the time required for 50% of the unit runoff to pass the point under consideration from the center of the unit rainfall excess. Several equations have been developed to estimate the watershed Lag. Both the United States Bureau of Reclamation (USBR) and the USACOE have utilized a form of the index equation $T_{lag} = 20K_n(L\ L_{ca}/S^{0.5})$ for unit hydrograph Lag time estimates. For this project, the USBR's lag equation will be utilized based upon the data analyzed and included in the USBR Flood Hydrology Manual (USBR, 1989) for the Southwest Desert and Great Basin watersheds. The K_n factor, representing the average Manning's n value for the principal watercourses in the watershed, will

be selected based upon field observations of similar principal watercourses. A conversion factor will then be applied to the USBR lag time to convert to an SCS lag time for use in the HEC-1 model.

Watershed Sizes

The size of the watersheds under investigation needs to balance the accuracy of the model with the accuracy of the data input for each watershed. With the use of high speed computers and automatic data generation software, the population of watershed data has been greatly accelerated such that more numerous watersheds can easily be analyzed, which produces more accurate peak flow estimates based upon the unit response of many smaller watersheds. For this project, watershed sizes will vary dependent upon the total area of the watershed as discussed in 7.2.5.1. Many of the subject watersheds are long and narrow with length to width ratios of 10 or 15 to 1. The use of smaller watersheds will be required in these areas to produce more accurate runoff results. The larger, long and narrow watersheds will be divided into watersheds with length to width ratios of 5 to 1 or less.

Hydrograph Routing

Routing of the specific watershed hydrographs will be modeled using the Muskingham-Cunge method. This method is expected to more closely model the field observed effects of overbank storage, rather than just translation of the hydrographs in time.

7.4 PALEOHYDROLOGY

An additional factor to be considered in determining the reasonableness of the peak flow estimates is the existence of evidence of past flood events within the specific watersheds. This evidence might consist of high water marks, vegetation deposits, scour lines, and other evidence indicative of flood events. This evidence can be very difficult to identify in the field until a peak flow estimate is generated. Once the peak flow estimate is generated, the field photographs will be reviewed to determine if any physical evidence exists upon which the peak flow estimate can be verified or refined. Any evidence found will then be used as supplemental data in determining the need for additional study and/or analysis of the watershed.

7.5 ANALYSIS SCOPE AND PROCEDURES

The following procedure will be utilized in the determination of hydrologic information needed for the MRC hydrologic analyses.

1. Test Watershed Analysis: A test watershed will be utilized to perform initial data extraction, watershed model set-up, model data population, and initial model runs. The model results will be reviewed for errors and will be compared to previous analysis by others to determine reasonableness and verify accuracy.

The model results will also be compared to results from gage and regional regression analysis to develop confidence intervals and error ranges for the watershed. The data necessary for this degree of analysis is available for only a few watersheds. The results will then be extrapolated to the remaining watersheds for use in determining the degree of confidence that can be placed on the hydrologic models for other watersheds.

This test analysis will also verify procedural accuracy and identify problems in model criteria, procedures, preparation, and application. Changes will be made, as necessary, to resolve all problems prior to application on a project-wide basis.

Several drainage areas were analyzed for test purposes and the results are summarized in the Attachment (Preliminary Hydrologic Study for Major Drainage Crossings.)

2. Model Parameters Sensitivity: A sensitivity analysis will be performed on all input parameters using approximate 10%, 50%, and 90% confidence interval range estimates to bracket the parameter sensitivities. This information will be used in a multiple parameter analysis to estimate confidence limits of the modeled results.

3. Watershed Modeling: Watershed models will be developed for all watershed areas impacting the MRC alignment. These models will be populated with the necessary analysis data and model runs will be performed.

4. Statistical Analysis: Statistical analysis of the existing stream gage data will be performed and the results compared to flows generated by the hydrologic modeling process.

5. Regression Analysis: Peak flow determination from the previously described regression equations will be performed at the MRC design points, where applicable to assist in error band evaluation of results from other methodologies.

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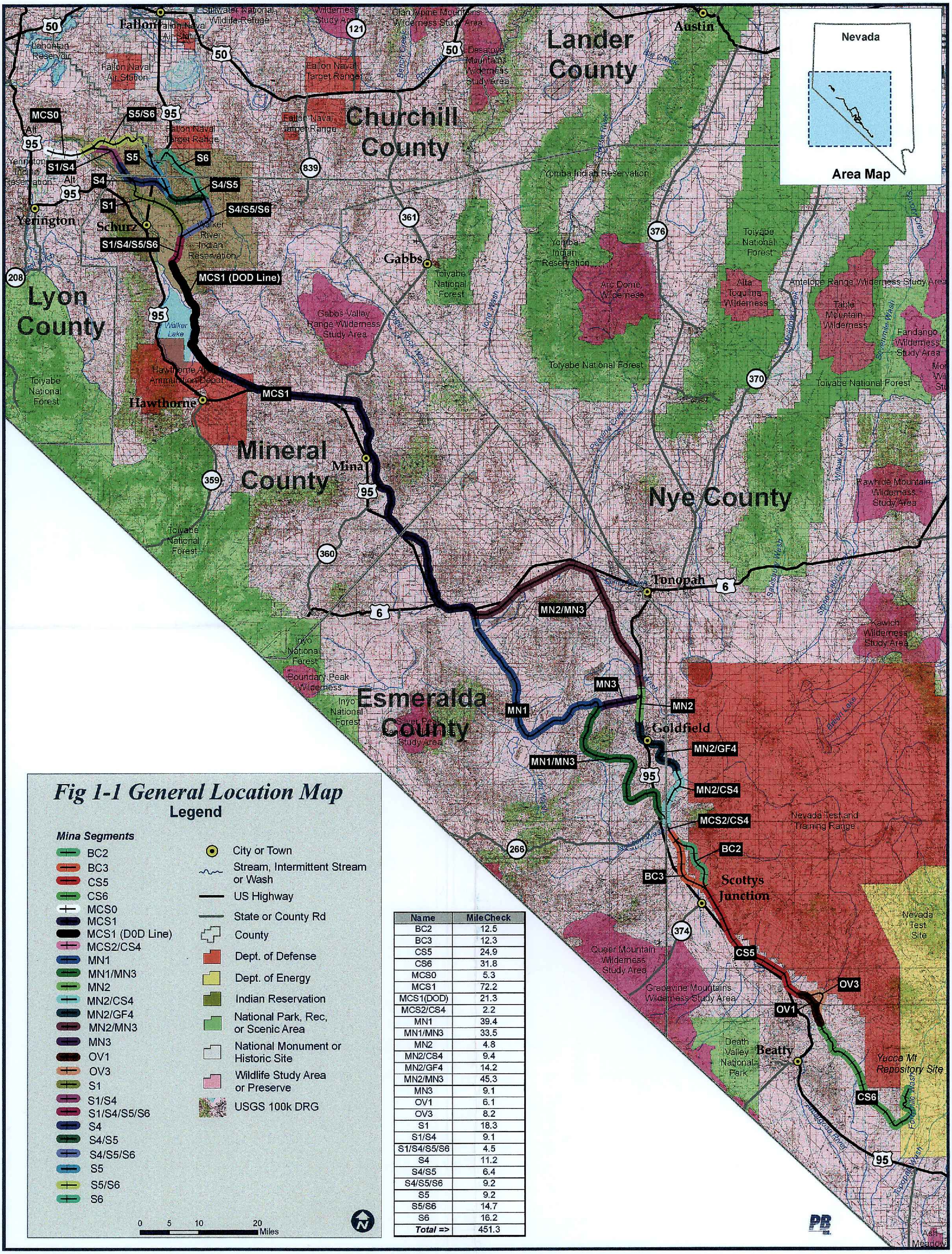

Name	MileCheck
BC2	12.5
BC3	12.3
CS5	24.9
CS6	31.8
MCS0	5.3
MCS1	72.2
MCS1(DOD)	21.3
MCS2/CS4	2.2
MN1	39.4
MN1/MN3	33.5
MN2	4.8
MN2/CS4	9.4
MN2/GF4	14.2
MN2/MN3	45.3
MN3	9.1
OV1	6.1
OV3	8.2
S1	18.3
S1/S4	9.1
S1/S4/S5/S6	4.5
S4	11.2
S4/S5	6.4
S4/S5/S6	9.2
S5	9.2
S5/S6	14.7
S6	16.2
Total =>	451.3

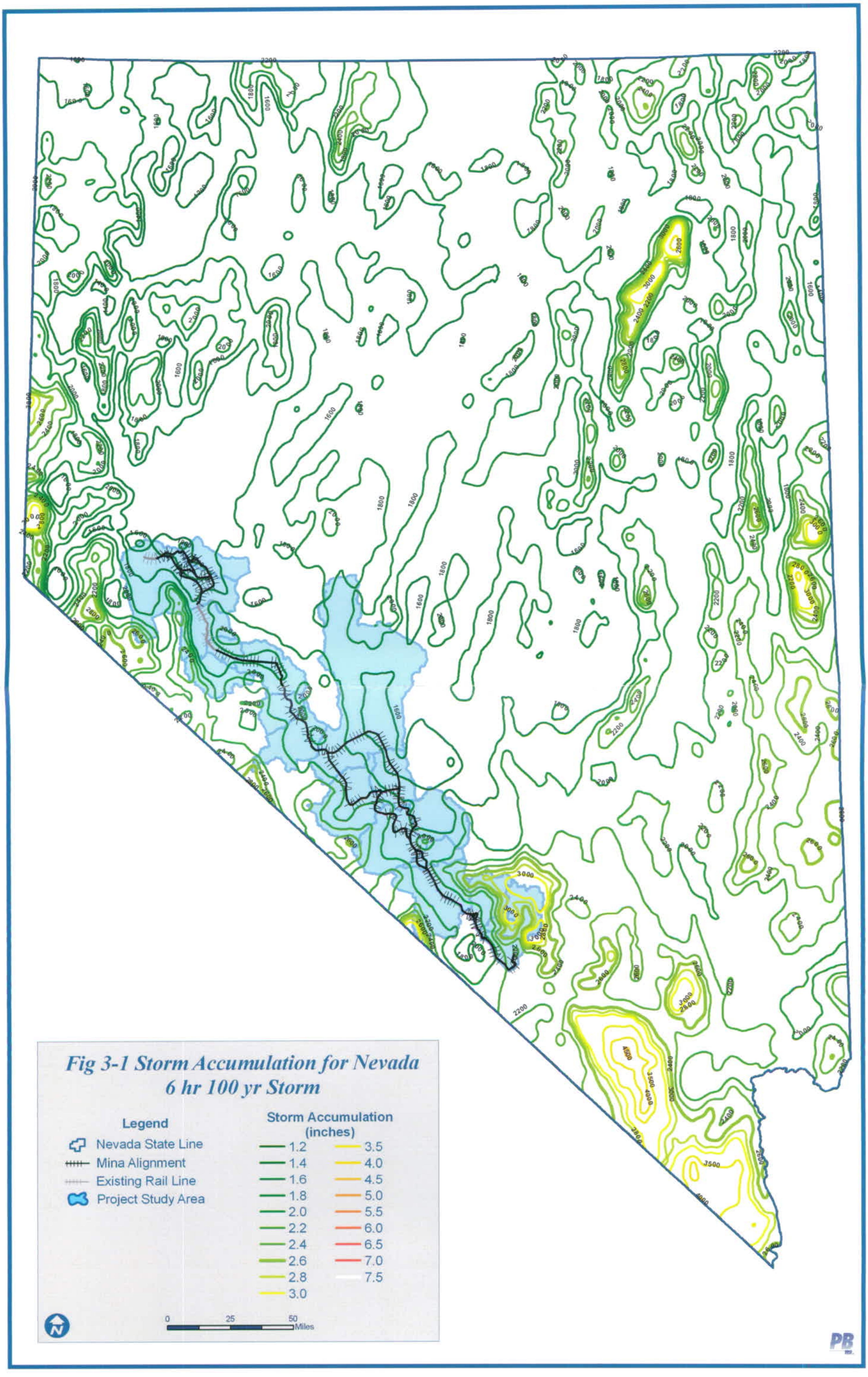

Fig 3-1 Storm Accumulation for Nevada
6 hr 100 yr Storm

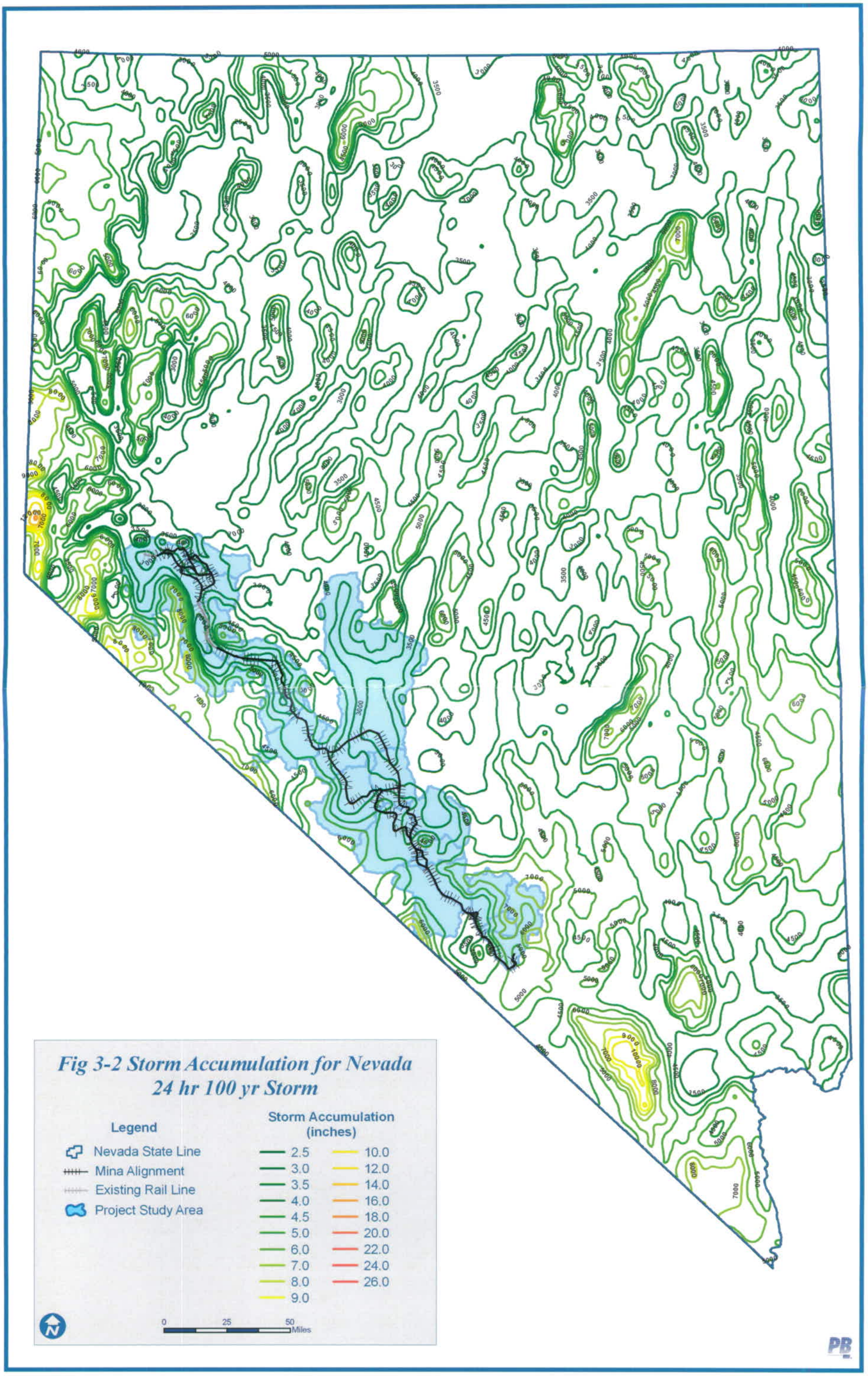
Fig 3-2 Storm Accumulation for Nevada
24 hr 100 yr Storm
Legend
Nevada State Line
Mina Alignment
Existing Rail Line
Project Study Area
Storm Accumulation (inches)
2.5
3.0
3.5
4.0
4.5
5.0
6.0
7.0
8.0
9.0
10.0
12.0
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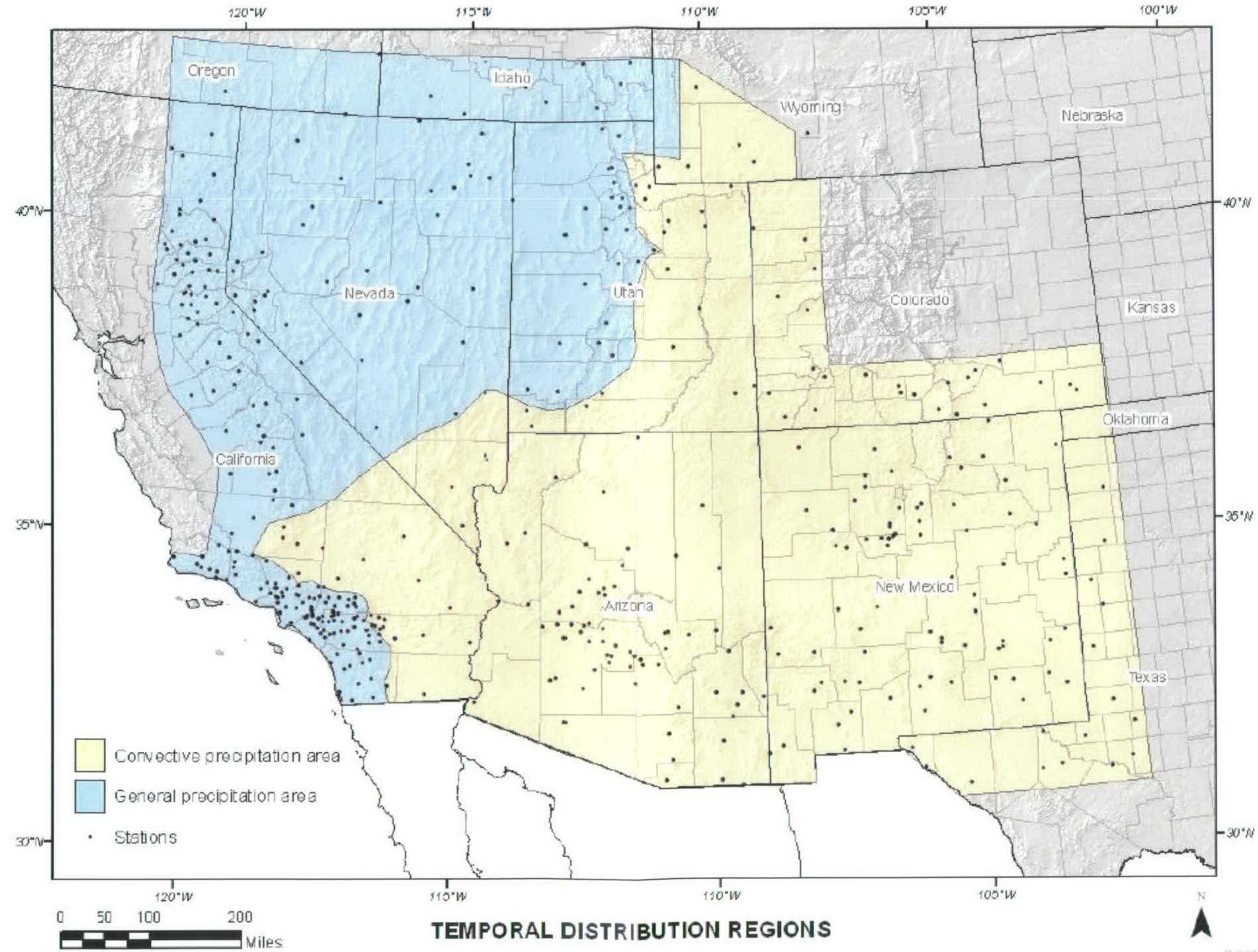
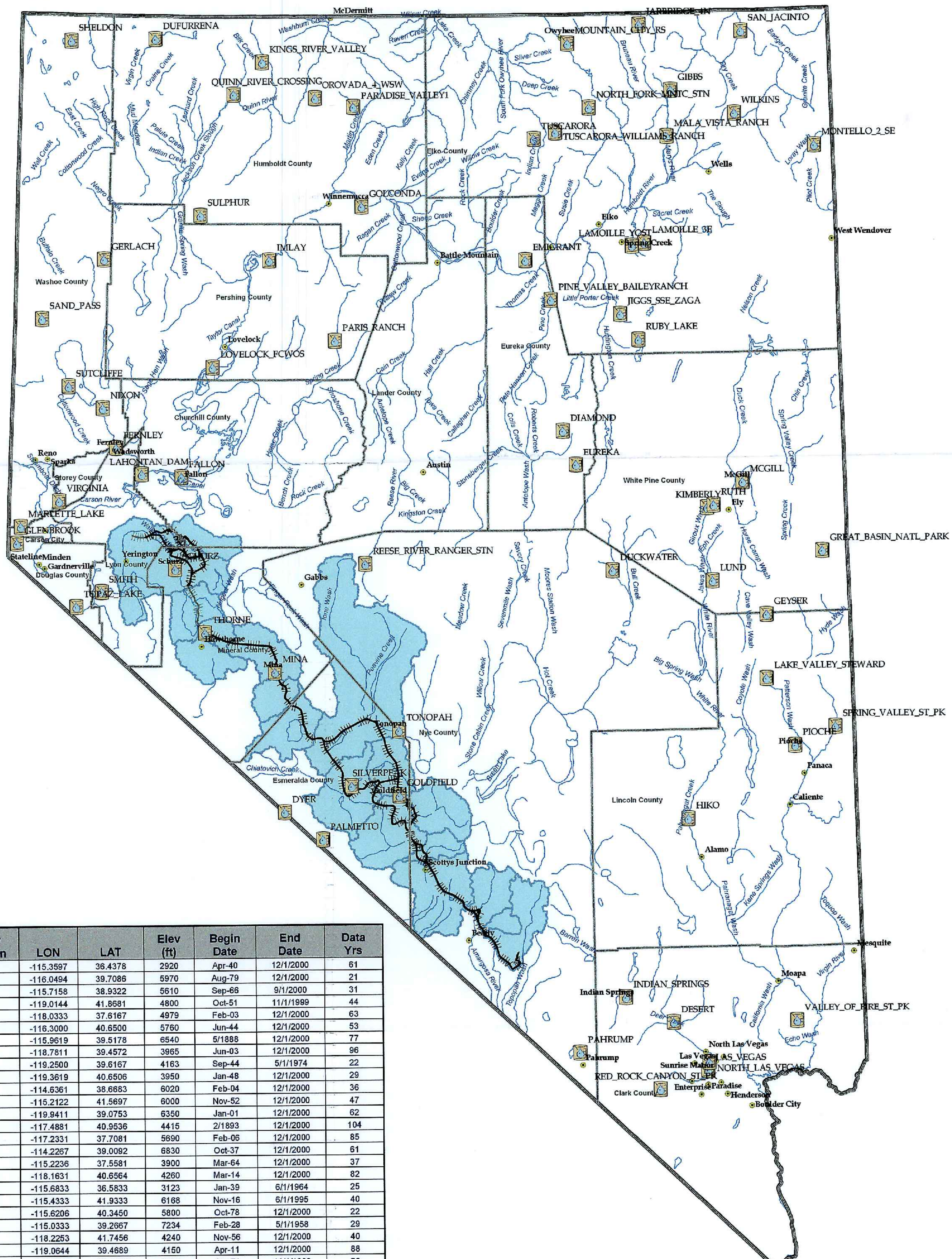
0
25
50
Miles
PB



TEMPORAL DISTRIBUTION REGIONS



ID	Name	ST	Daily Region	LON	LAT	Elev (ft)	Begin Date	End Date	Data Yrs
26-2243	DESERT	NV	19	-115.3597	36.4378	2920	Apr-40	12/1/2000	61
26-2296	DIAMOND	NV	11	-116.0494	39.7086	5970	Aug-79	12/1/2000	21
26-2390	DUCKWATER	NV	11	-115.7158	38.9322	5610	Sep-66	9/1/2000	31
26-2394	DUFURRENA	NV	3	-119.0144	41.8681	4800	Oct-51	11/1/1999	44
26-2431	DYER	NV	10	-118.0333	37.6167	4979	Feb-03	12/1/2000	63
26-2656	EMIGRANT	NV	11	-116.3000	40.6500	5760	Jun-44	12/1/2000	53
26-2708	EUREKA	NV	11	-115.9619	39.5178	6540	5/1888	12/1/2000	77
26-2780	FALLON	NV	10	-118.7811	39.4572	3965	Jun-03	12/1/2000	96
26-2840	FERNLEY	NV	3	-119.2500	39.6167	4163	Sep-44	5/1/1974	22
26-3090	GERLACH	NV	3	-119.3619	40.6506	3950	Jan-48	12/1/2000	29
26-3101	GEYSER	NV	11	-114.6361	38.6683	6020	Feb-04	12/1/2000	36
26-3114	GIBBS	NV	4	-115.2122	41.5697	6000	Nov-52	12/1/2000	47
26-3205	GLENBROOK	NV	9	-119.9411	39.0753	6350	Jan-01	12/1/2000	62
26-3245	GOLCONDA	NV	4	-117.4881	40.9536	4415	2/1893	12/1/2000	104
26-3285	GOLDFIELD	NV	10	-117.2331	37.7081	5690	Feb-06	12/1/2000	85
26-3340	GREAT_BASIN_NATL_PARK	NV	11	-114.2267	39.0092	6830	Oct-37	12/1/2000	61
26-3671	HIKO	NV	11	-115.2236	37.5581	3900	Mar-64	12/1/2000	37
26-3957	IMLAY	NV	10	-118.1631	40.6564	4260	Mar-14	12/1/2000	82
26-3980	INDIAN_SPRINGS	NV	19	-115.6833	36.5833	3123	Jan-39	6/1/1964	25
26-4038	JARBRIDGE_4N	NV	4	-115.4333	41.9333	6168	Nov-16	6/1/1995	40
26-4095	JIGGS_SSE_ZAGA	NV	11	-115.6206	40.3450	5800	Oct-78	12/1/2000	22
26-4199	KIMBERLY	NV	11	-115.0333	39.2667	7234	Feb-28	5/1/1958	29
26-4236	KINGS_RIVER_VALLEY	NV	4	-118.2253	41.7456	4240	Nov-56	12/1/2000	40
26-4349	LAHONTAN_DAM	NV	10	-119.0644	39.4689	4150	Apr-11	12/1/2000	88
26-4384	LAKE_VALLEY_STEWARD	NV	11	-114.6500	38.3167	6350	Jan-71	11/1/1998	28
26-4392	LAMOILLE_3E	NV	11	-115.4333	40.7333	6306	Jul-16	8/1/1975	54
26-4394	LAMOILLE_YOST	NV	11	-115.5231	40.7178	5840	Oct-75	12/1/2000	25
26-4429	LAS_VAGES	NV	19	-115.1333	36.1667	2011	6/1895	8/1/1956	53
26-4700	LOVELOCK_FCWOS	NV	10	-118.5653	40.0664	3900	Jul-48	11/1/2000	49
26-4745	LUND	NV	11	-115.0092	38.8625	5560	Aug-57	12/1/2000	43
26-4824	MALA_VISTA_RANCH	NV	4	-115.2500	41.3167	5594	May-39	6/1/1965	26
26-4858	MARLETTE_LAKE	NV	9	-119.9167	39.1667	8005	Dec-13	7/1/1952	25
26-4950	MCGILL	NV	11	-114.7764	39.4014	6270	1/1892	12/1/2000	93
26-5168	MINA	NV	10	-118.1058	38.3867	4550	3/1896	12/1/2000	104
26-5352	MONTELLO_2_SE	NV	11	-114.1728	41.2428	4900	4/1895	12/1/2000	103
26-5392	MOUNTAIN_CITY_RS	NV	4	-115.9653	41.8375	5650	Feb-55	11/1/1999	45
26-5605	NIXON	NV	3	-119.3500	39.8333	3904	May-28	11/1/1974	36
26-5691	NORTH_FORK_MNTC_STN	NV	4	-115.8167	41.4833	6204	Nov-09	10/1/1970	49
26-5705	NORTH_LAS_VEGAS	NV	19	-115.1231	36.2108	1880	Feb-51	12/1/2000	49
26-5818	OROVADA_4_WSW	NV	4	-117.8333	41.5500	4290	Aug-11	12/1/2000	85
26-5890	PAHRUMP	NV	19	-116.0031	36.2786	2674	Mar-14	12/1/2000	52
26-5931	PALMETTO	NV	10	-117.7667	37.4667	5906	3/1890	9/1/1951	22
26-6005	PARADISE_VALLEY1	NV	4	-117.5478	41.5022	4675	2/1894	12/1/2000	89
26-6055	PARIS_RANCH	NV	10	-117.6833	40.2167	4140	Jul-66	10/1/1991	25
26-6242	PINE_VALLEY_BAILEYRANCH	NV	11	-116.1200	40.4294	5047	Oct-56	12/1/2000	43
26-6252	PIOCHE	NV	11	-114.4661	37.9444	6180	1/1888	11/1/2000	71
26-6504	QUINN_RIVER_CROSSING	NV	4	-118.4333	41.5667	4091	Feb-01	3/1/1951	28
26-6691	RED_ROCK_CANYON_ST_PK	NV	20	-115.4603	36.0686	3780	May-77	12/1/2000	24
26-6746	REESE_RIVER_RANGER_STN	NV	11	-117.4667	38.9833	6649	Apr-72	12/1/2000	27
26-7123	RUBY_LAKE	NV	11	-115.4928	40.2028	6010	Jan-40	12/1/2000	60
26-7175	RUTH	NV	11	-114.9875	39.2800	6840	Jun-58	11/1/2000	36
26-7284	SAN_JACINTO	NV	4	-114.6833	41.8833	5203	Sep-04	9/1/1948	43
26-7261	SAND_PASS	NV	3	-119.8000	40.3167	3904	Oct-13	9/1/1971	52
26-7358	SCHURZ	NV	10	-118.8167	38.9500	4124	Jan-20	4/1/1957	36
26-7443	SHELDON	NV	3	-119.6333	41.8500	6506	Jul-33	2/1/1972	38
26-7463	SILVERPEAK	NV	10	-117.5653	37.7619	4260	Oct-67	12/1/2000	33
26-7609	SMITH	NV	10	-119.3333	38.8167	4754	Jul-08	9/1/1966	57
26-7750	SPRING_VALLEY_ST_PK	NV	11	-114.1800	38.0406	5950	Aug-74	12/1/2000	26
26-7873	SULPHUR	NV	3	-118.6667	40.9000	4042	Sep-14	1/1/1953	36
26-7953	SUTCLIFFE	NV	3	-119.5983	39.9503	3900	Jun-67	12/1/2000	28
26-8034	THORNE	NV	10	-118.6000	38.6000	4203	Apr-14	5/1/1950	34
26-8160	TONOPAH	NV	11	-117.2333	38.0667	6024	May-02	6/1/1954	31
26-8186	TOPAZ_LAKE	NV	10	-119.5100	38.7319	5105	Jul-57	12/1/1985	26
26-8346	TUSCARORA	NV	4	-116.2244	41.3161	6170	May-57	12/1/2000	40
26-8349	TUSCARORA_WILLIAMS_RANCH	NV	4	-116.0667	41.3500	6404	9/1888	11/1/1956	46
26-8588	VALLEY_OF_FIRE_ST_PK	NV	19	-114.5142	36.4297	2000	Dec-72	12/1/2000	28
26-8761	VIRGINIA	NV	3	-119.6483	39.3128	6340	Apr-51	12/1/2000	46
26-9122	WILKINS	NV	4	-114.7500	41.4333	5643	Jul-48	5/1/1980	21

Fig 3-4 Nevada Precipitation Stations

Nevada
County
Hydro Sub-basin
Mina Alignment
Existing Rail Line
Stream
Precipitation Station
City

0 25 50 100 Miles

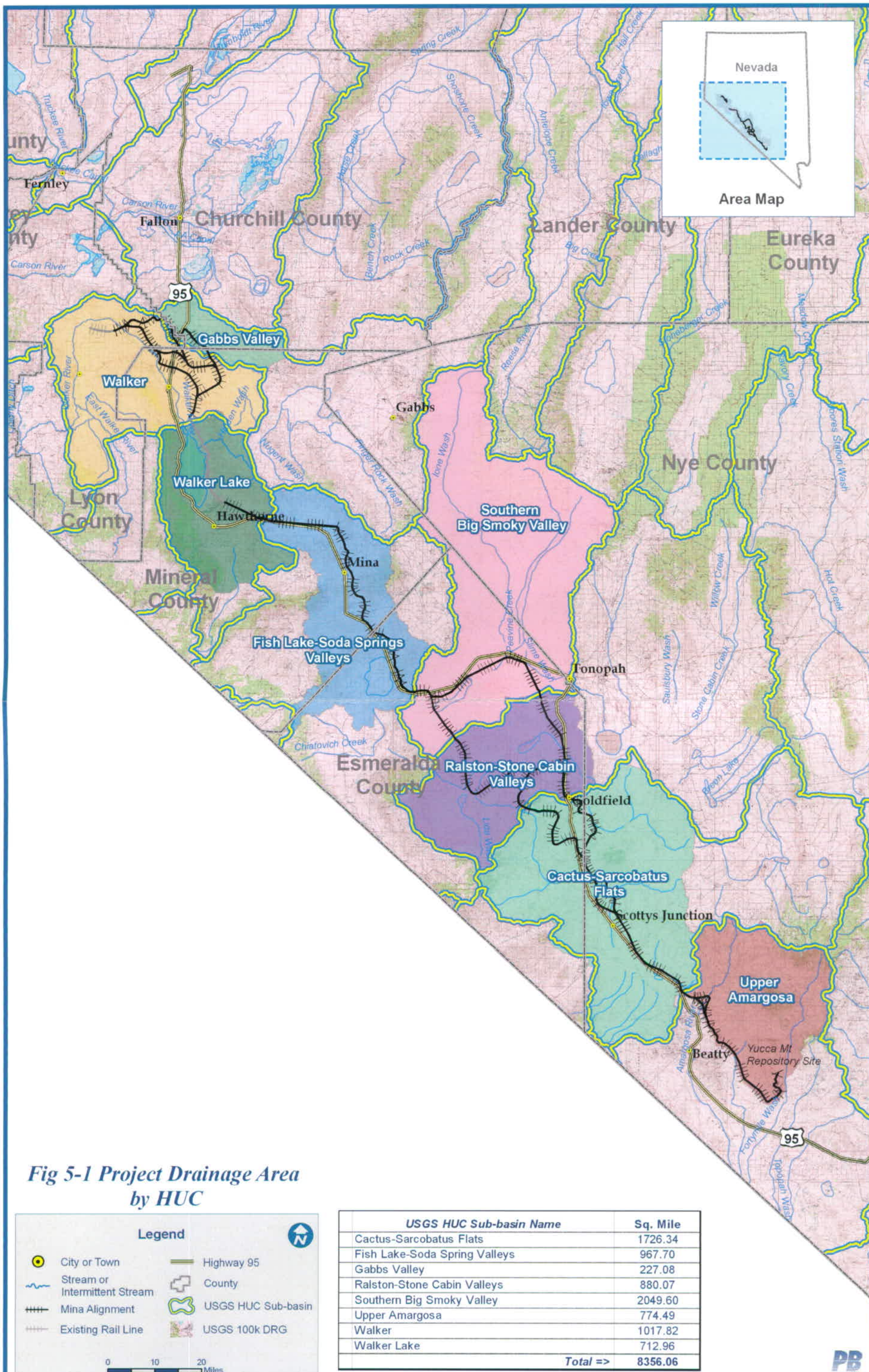


Fig 5-1 Project Drainage Area by HUC

USGS HUC Sub-basin Name	Sq. Mile
Cactus-Sarcobatus Flats	1726.34
Fish Lake-Soda Spring Valleys	967.70
Gabbs Valley	227.08
Ralston-Stone Cabin Valleys	880.07
Southern Big Smoky Valley	2049.60
Upper Amargosa	774.49
Walker	1017.82
Walker Lake	712.96
Total =>	**8356.06**

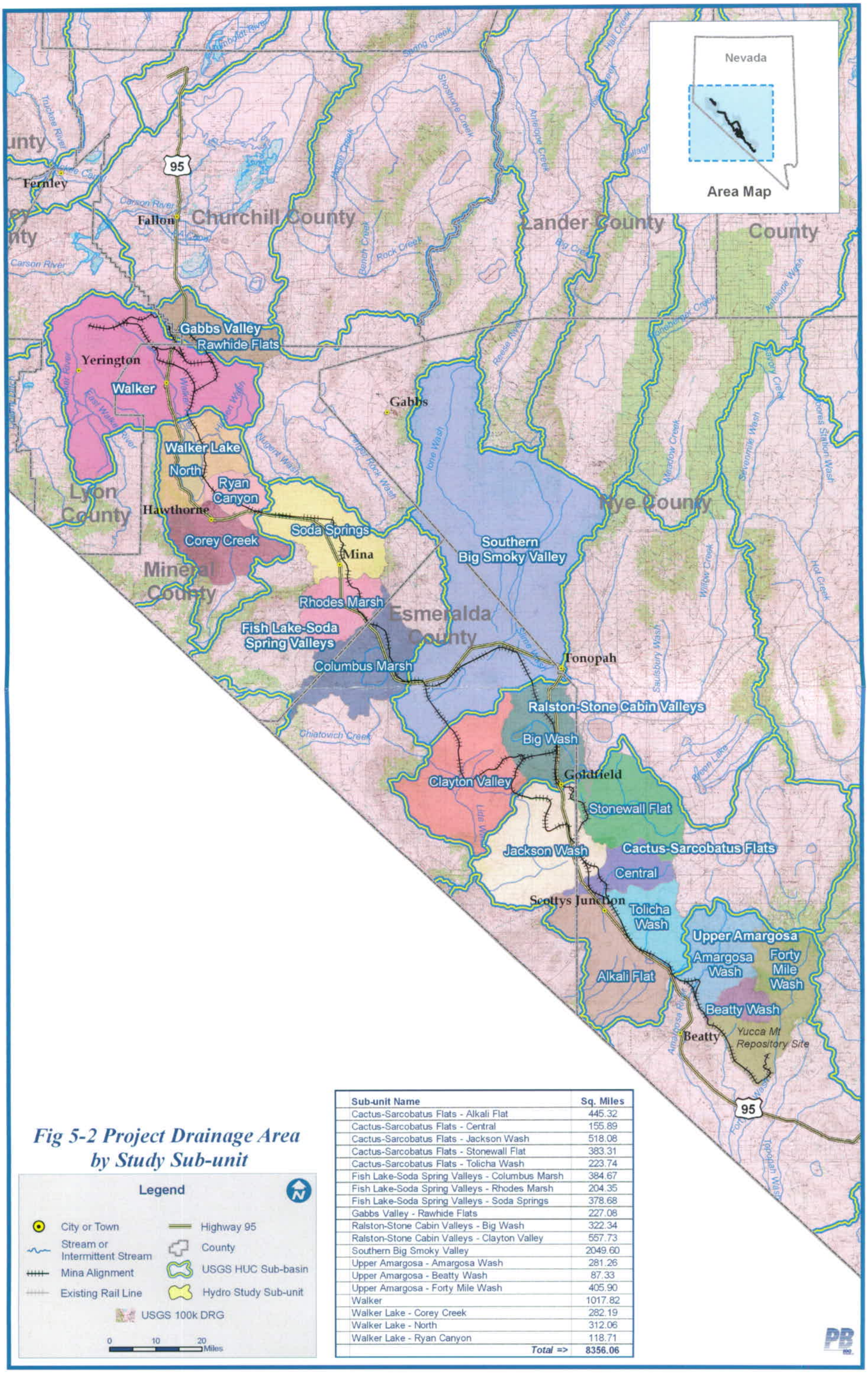
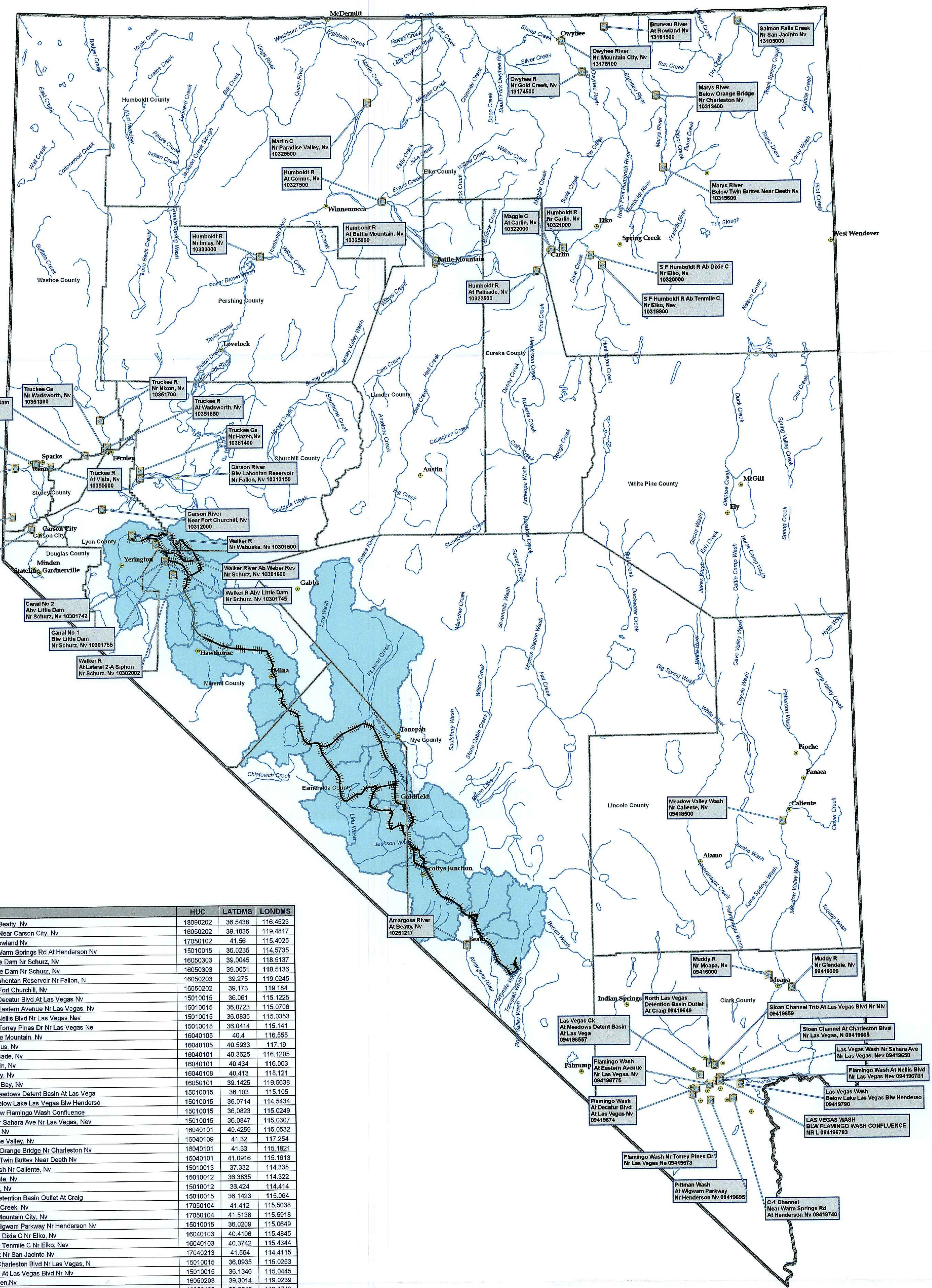


Fig 5-2 Project Drainage Area by Study Sub-unit

Sub-unit Name	Sq. Miles
Cactus-Sarcobatus Flats - Alkali Flat	445.32
Cactus-Sarcobatus Flats - Central	155.89
Cactus-Sarcobatus Flats - Jackson Wash	518.08
Cactus-Sarcobatus Flats - Stonewall Flat	383.31
Cactus-Sarcobatus Flats - Tolicha Wash	223.74
Fish Lake-Soda Spring Valleys - Columbus Marsh	384.67
Fish Lake-Soda Spring Valleys - Rhodes Marsh	204.35
Fish Lake-Soda Spring Valleys - Soda Springs	378.68
Gabbs Valley - Rawhide Flats	227.08
Ralston-Stone Cabin Valleys - Big Wash	322.34
Ralston-Stone Cabin Valleys - Clayton Valley	557.73
Southern Big Smoky Valley	2049.60
Upper Amargosa - Amargosa Wash	281.26
Upper Amargosa - Beatty Wash	87.33
Upper Amargosa - Forty Mile Wash	405.90
Walker	1017.82
Walker Lake - Corey Creek	282.19
Walker Lake - North	312.06
Walker Lake - Ryan Canyon	118.71
Total =>	**8356.06**

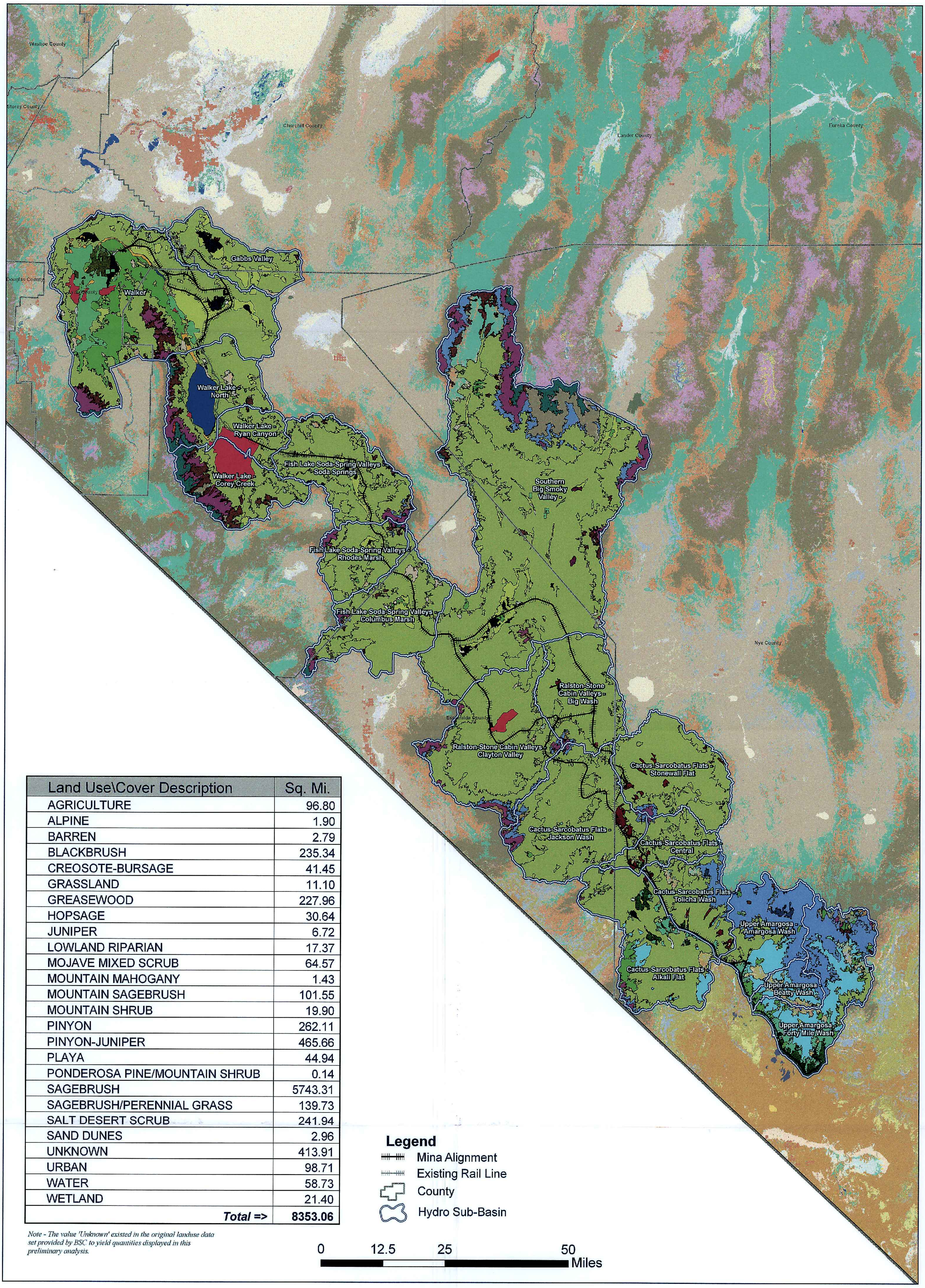


STAID	STANAME	HUC	LATDMS	LONDMS
10251217	Amargosa River At Beatty, Nv	18090202	36.5438	116.4523
10311200	Ash Canyon Creek Near Carson City, Nv	16050202	39.1035	119.4817
13161500	Bruneau River At Rowland Nv	17050102	41.56	115.4025
09419740	C-1 Channel Near Warm Springs Rd At Henderson Nv	15010015	36.0235	114.5735
10301755	Canal No 1 Blw Little Dam Nr Schurz, Nv	16050303	39.0045	118.5137
10301742	Canal No 2 Abv Little Dam Nr Schurz, Nv	16050303	39.0051	118.5136
10312150	Carson River Blw Lahontan Reservoir Nr Fallon, N	16050203	39.275	119.0245
10312000	Carson River Near Fort Churchill, Nv	16050202	39.173	119.184
09419674	Flamingo Wash At Decatur Blvd At Las Vegas Nv	15010015	36.061	115.1225
094196775	Flamingo Wash At Eastern Avenue Nr Las Vegas, Nv	15010015	36.0723	115.0706
094196781	Flamingo Wash At Nellis Blvd Nr Las Vegas Nev	15010015	36.0835	115.0353
09419673	Flamingo Wash Nr Torrey Pines Dr Nr Las Vegas Ne	15010015	36.0414	115.141
10325000	Humboldt R At Battle Mountain, Nv	16040105	40.4	116.555
10327500	Humboldt R At Comus, Nv	16040105	40.5933	117.19
10322500	Humboldt R At Palisade, Nv	16040101	40.3625	116.1205
10321000	Humboldt R Nr Carlin, Nv	16040101	40.434	116.003
10333000	Humboldt R Nr Imlay, Nv	16040108	40.413	118.121
10336700	Incline C Nr Crystal Bay, Nv	16050101	39.1425	119.5638
094196557	Las Vegas Ck At Meadows Detent Basin At Las Vega	15010015	36.103	115.105
09419790	Las Vegas Wash Below Lake Las Vegas Blw Henderso	15010015	36.0714	114.5434
094196783	Las Vegas Wash Blw Flamingo Wash Confluence	15010015	36.0823	115.0249
09419658	Las Vegas Wash Nr Sahara Ave Nr Las Vegas, Nev	15010015	36.0847	115.0307
10322000	Maggie C At Carlin, Nv	16040101	40.4259	116.0532
10329500	Martin C Nr Paradise Valley, Nv	16040109	41.32	117.254
10313400	Marys River Below Orange Bridge Nr Charleston Nv	16040101	41.33	115.1821
10315600	Marys River Below Twin Buttes Near Deeth Nv	16040101	41.0916	115.1613
09418500	Meadow Valley Wash Nr Caliente, Nv	15010013	37.332	114.335
09419000	Muddy R Nr Glendale, Nv	15010012	36.3835	114.322
09416000	Muddy R Nr Moapa, Nv	15010012	36.424	114.414
09419649	North Las Vegas Detention Basin Outlet At Craig	15010015	36.1423	115.064
13174500	Owyhee R Nr Gold Creek, Nv	17050104	41.412	115.5038
13175100	Owyhee River Nr. Mountain City, Nv	17050104	41.5138	115.5918
09419695	Pittman Wash At Wigwam Parkway Nr Henderson Nv	15010015	36.0209	115.0649
10320000	S F Humboldt R Ab Dixie C Nr Elko, Nv	16040103	40.4106	115.4845
10319900	S F Humboldt R Ab Tenmile C Nr Elko, Nev	16040103	40.3742	115.4344
13105000	Salmon Falls Creek Nr San Jacinto Nv	17040213	41.564	114.4115
09419665	Sloan Channel At Charleston Blvd Nr Las Vegas, N	15010015	36.0935	115.0253
09419659	Sloan Channel Trib At Las Vegas Blvd Nr Nlv	15010015	36.1346	115.0445
10351400	Truckee Ca Nr Hazen,Nv	16050203	39.3014	119.0239
10351300	Truckee Ca Nr Wadsworth, Nv	16050102	39.3646	119.1746
10348000	Truckee R At Reno,Nv	16050102	39.3153	119.4707
10350000	Truckee R At Vista, Nv	16050102	39.3105	119.4058
10351650	Truckee R At Wadsworth, Nv	16050103	39.3756	119.1656
10351600	Truckee R Bl Derby Dam Nr Wadsworth, Nv	16050102	39.3505	119.2625
10351700	Truckee R Nr Nixon, Nv	16050103	39.464	119.201
10347460	Truckee River Near Mogul, Nv	16050102	39.3026	119.5551
10301745	Walker R Abv Little Dam Nr Schurz, Nv	16050303	39.0049	118.5136
10302002	Walker R At Lateral 2-A Siphon Nr Schurz, Nv	16050303	38.5625	118.481
10301500	Walker R Nr Wabuska, Nv	16050303	39.091	119.055
10301600	Walker River Ab Weber Res Nr Schurz, Nv	16050303	39.0612	118.5542

Fig 3-5 Nevada Stream Gage Stations

Nevada
County
Hydro Sub-basin
Mina Alignment
Existing Rail Line
Stream
Stream Gage
City

0 25 50 100 Miles



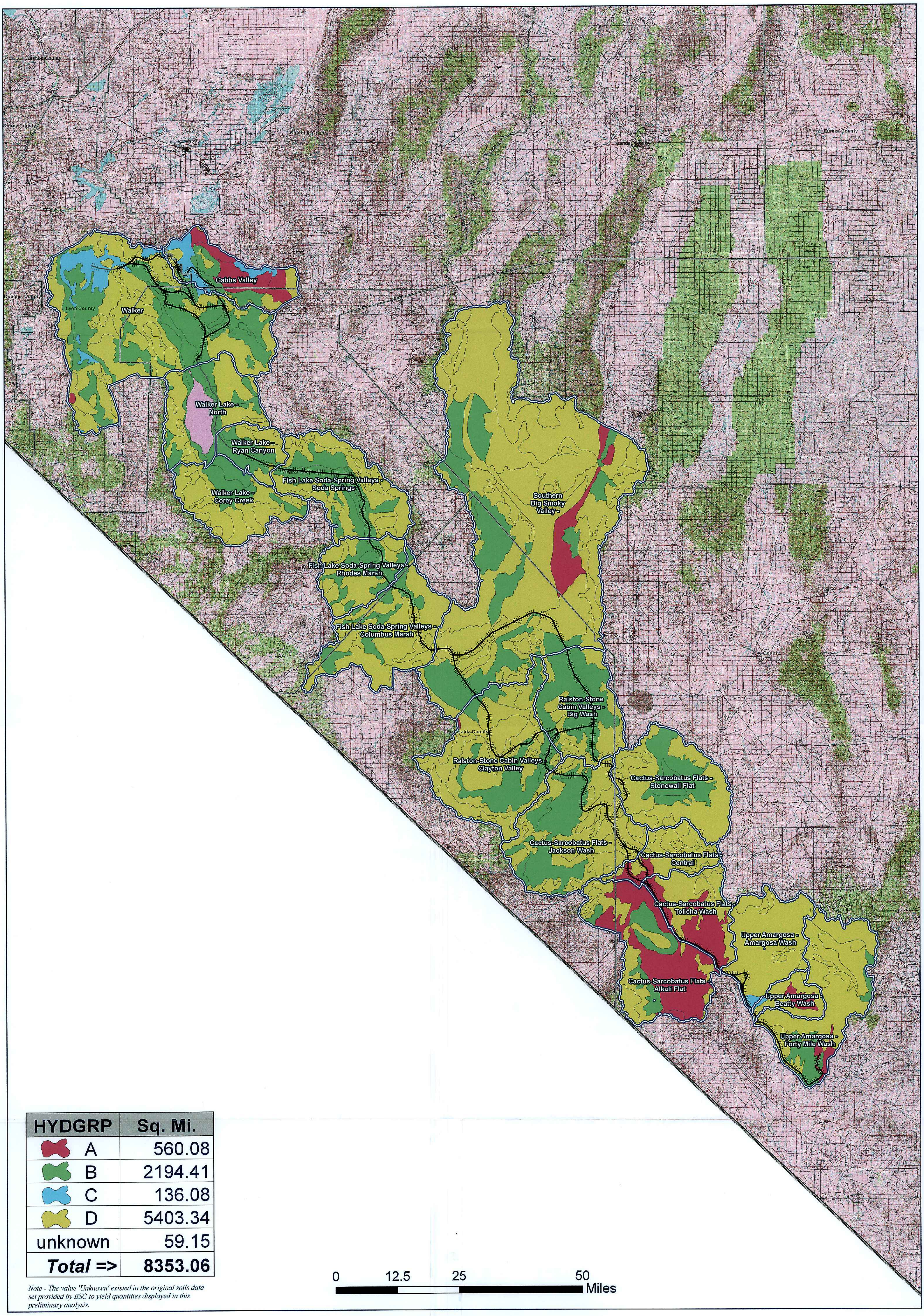
Land Use\Cover Description	Sq. Mi.
AGRICULTURE	96.80
ALPINE	1.90
BARREN	2.79
BLACKBRUSH	235.34
CREOSOTE-BURSAGE	41.45
GRASSLAND	11.10
GREASEWOOD	227.96
HOPSAGE	30.64
JUNIPER	6.72
LOWLAND RIPARIAN	17.37
MOJAVE MIXED SCRUB	64.57
MOUNTAIN MAHOGANY	1.43
MOUNTAIN SAGEBRUSH	101.55
MOUNTAIN SHRUB	19.90
PINYON	262.11
PINYON-JUNIPER	465.66
PLAYA	44.94
PONDEROSA PINE/MOUNTAIN SHRUB	0.14
SAGEBRUSH	5743.31
SAGEBRUSH/PERENNIAL GRASS	139.73
SALT DESERT SCRUB	241.94
SAND DUNES	2.96
UNKNOWN	413.91
URBAN	98.71
WATER	58.73
WETLAND	21.40
Total =>	**8353.06**

Note - The value 'Unknown' existed in the original landuse data set provided by BSC to yield quantities displayed in this preliminary analysis.

Fig 3-6 Study Area Land Use\Cover

AGRICULTURE
ALPINE
BARREN
BLACKBRUSH
CREOSOTE-BURSAGE
GRASSLAND
GREASEWOOD
HOPSAGE
JUNIPER
LOWLAND RIPARIAN
MOJAVE MIXED SCRUB
MOUNTAIN MAHOGANY
MOUNTAIN SAGEBRUSH
MOUNTAIN SHRUB
PINYON
PINYON-JUNIPER
PLAYA
PONDEROSA PINE/MOUNTAIN SHRUB
SAGEBRUSH
SAGEBRUSH/PERENNIAL GRASS
SALT DESERT SCRUB
SAND DUNES
URBAN
WATER
WETLAND

PB



HYDGRP	Sq. Mi.
A	560.08
B	2194.41
C	136.08
D	5403.34
unknown	59.15
Total =>	**8353.06**

Note - The value 'Unknown' existed in the original soils data set provided by BSC to yield quantities displayed in this preliminary analysis.

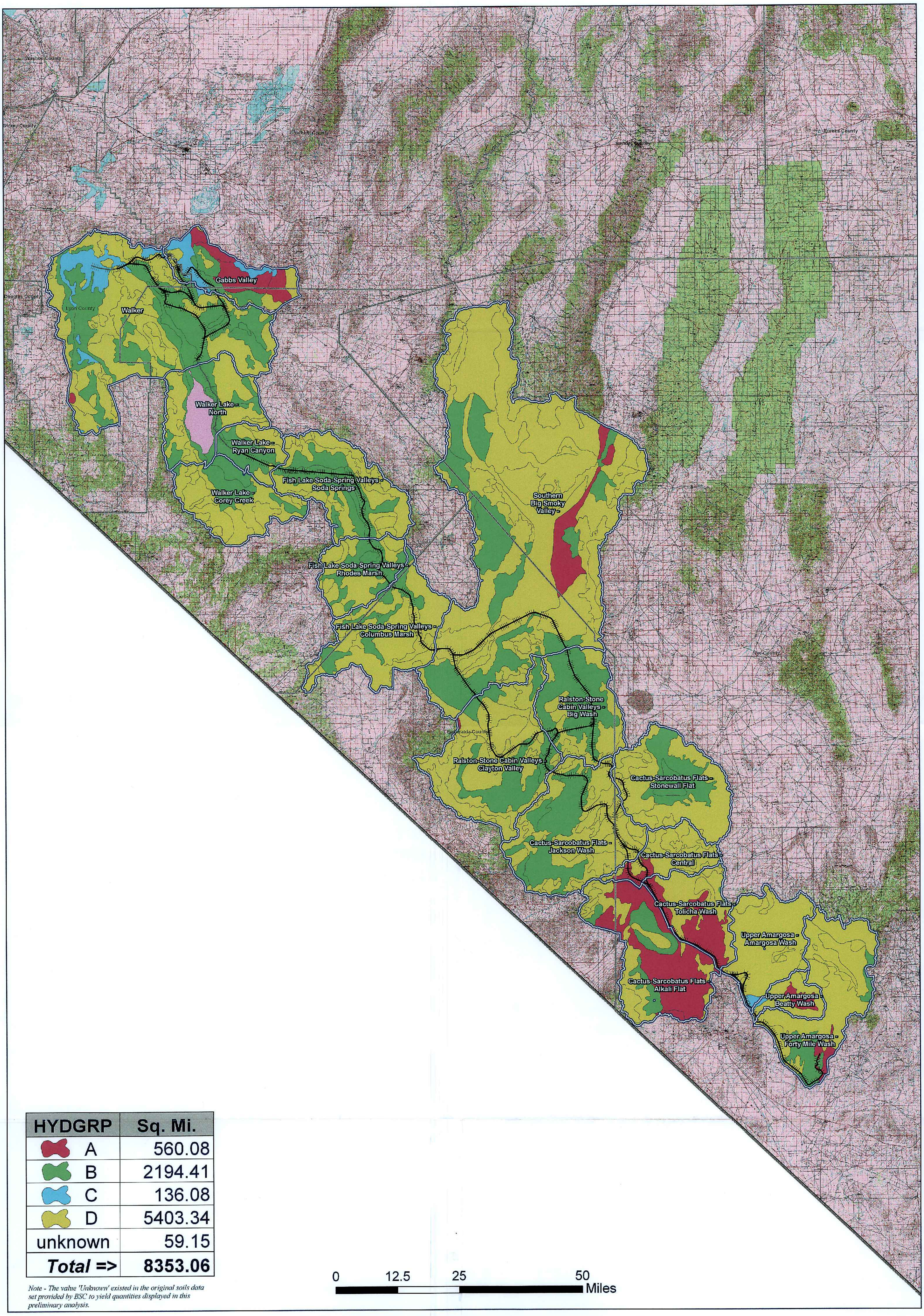
Fig 3-7 Study Area Soils

County

Hydro Sub-Basin

Mina Alignment

Existing Rail Line



HYDGRP	Sq. Mi.
A	560.08
B	2194.41
C	136.08
D	5403.34
unknown	59.15
Total =>	**8353.06**

Note - The value 'Unknown' existed in the original soils data set provided by BSC to yield quantities displayed in this preliminary analysis.

Fig 3-7 Study Area Soils

County
Hydro Sub-Basin
Mina Alignment
Existing Rail Line

PRELIMINARY HYDROLOGIC STUDY FOR MAJOR DRAINAGE CROSSINGS

MINA RAIL CORRIDOR
YUCCA MOUNTAIN PROJECT, NEVADA

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1. INTRODUCTION

The Mina Rail Corridor (MRC) is a proposed railroad route for the Yucca Mountain project. The route goes through the Great Basin in southwest part of Nevada. The total length of the alignment is about 265 miles. The major portion of the MRC alignment is parallel to State Highway 95 (US95).

This report focuses on the major washes/crossings along US 95 within MRC study limit in the area south of Schurz and north of Beatty. The tributary drainage area and design locations presented in this report apply US 95 as the base line reference.

The MRC will be impacted by a tributary drainage area of approximately 8,356 square miles as shown in Table 1 and Figure 5.2. Most of these natural washes are ungaged. The purpose of this report is to investigate 100-year peak flood flows through the major crossings along the US95 from Beatty to Hawthorne and then establish a regional hydrologic method by which flood flows along the MRC can be consistently estimated.

Table 1 - Major Washes within Mina Rail Corridor

	Major Wash in Watershed	Area (mile^2)
1	Upper Amargosa - Forty Mile Wash	406
2	Upper Amargosa - Beatty Wash	87
3	Upper Amargosa - Amargosa Wash	281
4	Cactus-Sarcobatus Flats - Tolicha Wash	224
5	Ralston-Stone Cabin Valleys - Clayton Valley	558
6	Ralston-Stone Cabin Valleys - Big Wash	322
7	Fish Lake – Soda Spring Valleys - Columbus Marsh	385
8	Fish Lake – Soda Spring Valleys - Rhodes Marsh	204
9	Cactus-Sarcobatus Flats - Central	156
10	Ralston-Stone Cabin Valleys - Jackson Wash	518
11	Cactus-Sarcobatus Flats - Stonewall Flat	383
12	Walker Lake - Ryan Canyon	119
13	Walker Lake - Corey Creek	282
14	Walker Lake - North	312
15	Fish Lake – Soda Spring Valleys - Soda Springs	379
16	Walker	1,018
17	Cactus-Sarcobatus Flats - Alkali Flat	445
18	Southern Big Smoky Valley	2,050
19	Gabbs Valley – Rawhide Flats	227
	Total	8,356

The hydrologic analysis for an area of more than 8,300 square miles is a regional effort that needs specific guidelines and protocols to maintain the hydrologic consistency when selecting models, methods, parameters and design events. As recommended in the Hydrologic and Drainage Evaluation Report, 2005, a Watershed Analysis Plan (WAP) will be developed using several sample watersheds. In this study, the existing major drainage crossings under US95 serve as a reference to select the sample watersheds. This pilot effort will begin with the collection of basic hydrologic information and recommend standardized procedures for prediction of peak runoff rates and volumes within the project limits. The WAP for the MRC will be divided into three sections. The first section is to present the basic hydrologic information of the design rainfall intensity and the computer modeling technique. The second section is the watershed delineation and compares the calculation results to the drainage capacities of the existing crossings under US95. Lastly, the third section outlines the regression analyses and protocols of the flood predictions along the MRC. This report will make a recommendation as to how to select the railroad low cord elevations along the proposed MRC alignment based on the hydrologic study and field survey. Detailed calculations for this analysis can be found in the appendixes.

2. DESIGN RAINFALL DEPTH AND DISTRIBUTION

In Nevada, almost all of the major storm events typically track from west to east or southwest to northeast. However, the aspect of the larger watersheds tributary to the MRC is generally from north to south. There are a few rain and stream gage stations located within the MRC watersheds, however, the majority have less than twenty (20) years of record. Most of the study area receives less than 10 inches of precipitation per year and much of this precipitation occurs during the winter months as snow fall or low intensity rainfall. During the summer months, many areas experience only one or two thunderstorm events per year. As a result, many stream flow gages record no flow for the entire year.

2.1 Types of Storms

According to NOAA Atlas 14 Volume 1, general and convective rainfall distributions were established for the southwest region in the Unites States as shown in Figure 1. The maximum precipitation events in the general rainfall distribution area are dominated by cold season precipitation cases while the maximum precipitation events in the convective precipitation area occur during the warm season.

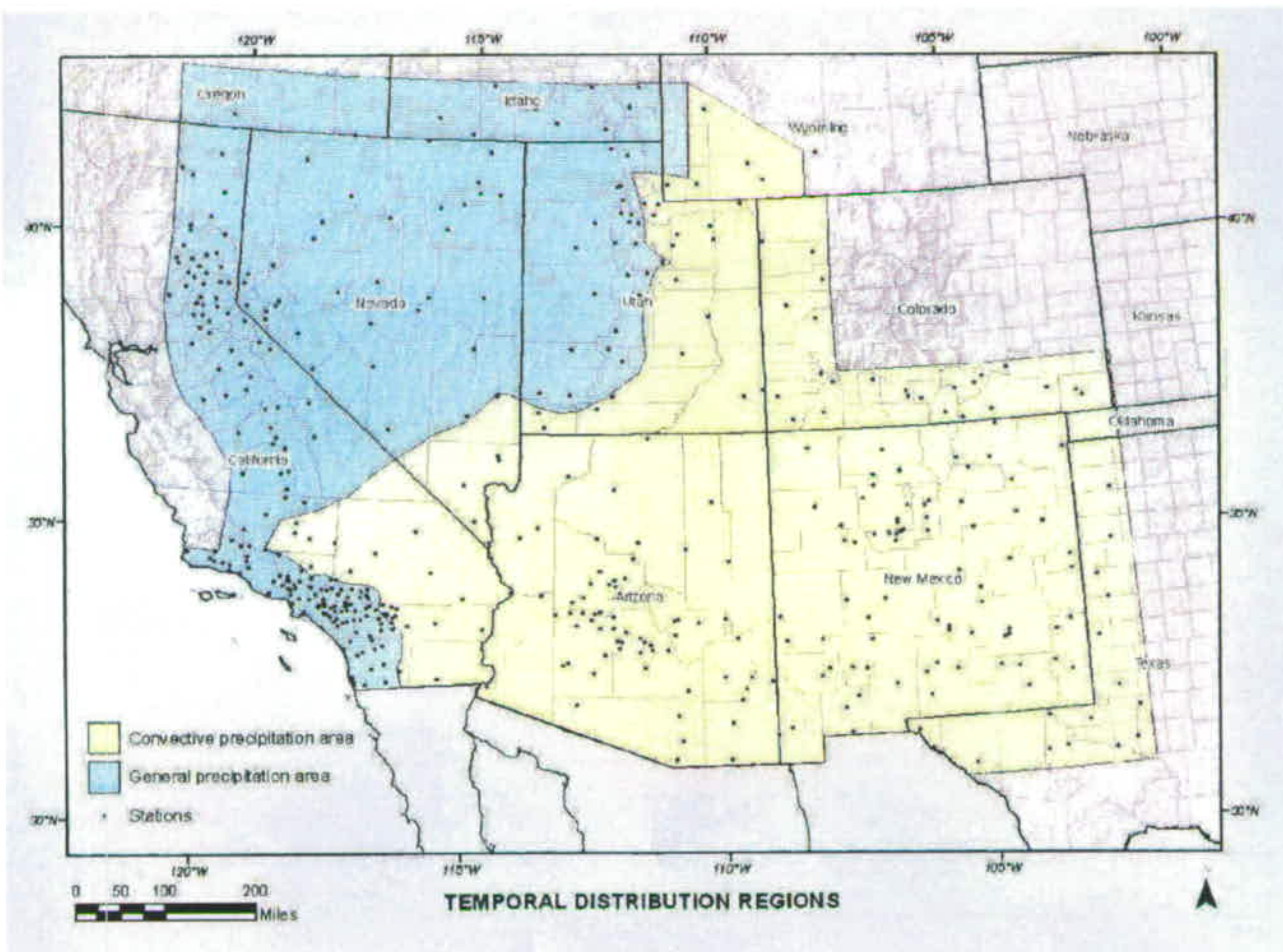

Figure 1 - General and Convective Precipitation Areas in Southwest Region of USA

2.2 Temporal Distributions

According to NOAA Atlas 14, Volume 1, observed rainfall depths during an event are converted to cumulative curves in time. Each of the accumulations is then converted to a normalized curve using the ratio of the cumulative hourly precipitation to the total precipitation across the event duration. Thus, the last value of the summation ratios is always 100%. The normalized rainfall curves are separated into categories by the quartile in which the greatest increment of the total percentage occurred. A majority of the observed storm events analyzed for the southwest region fall into the first-quartile case. Fewer and fewer cases fall into each of the subsequent quartile categories with the fourth quartile containing the fewest number of cases.

Using the above procedure, NOAA Atlas 14, Volume 1, provides the following four quartile-based temporal distributions of heavy precipitation for use with various precipitation return periods: 6-, 12, 24-, and 96-hour durations for the southwest region. Figures 2 and 3 present the median values for the first-quartile 24-hour general and convective rainfall distribution curves, respectively. The X-axis, T/T24, is the cumulative percentage of time, T, to duration of 24 hours. The Y-axis, P/P24, is the cumulative percentage of precipitation, P, to total precipitation, P24. These two 24-hour rainfall curves were derived from numerous data using statistical approaches and may not be the same as the temporal distributions of single storms. In comparison, the convective precipitation distribution shows a steeper gradient than the general precipitation distribution and therefore, depicts an early intense period that produces a higher peak runoff flow rate.

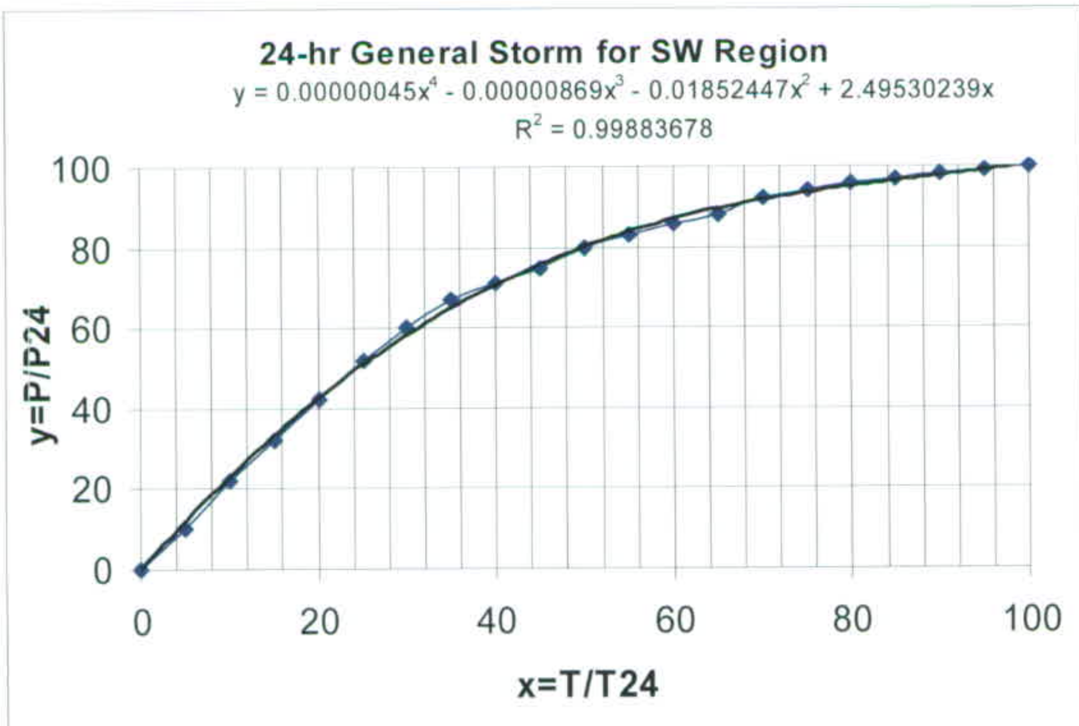

Figure 2 -Temporal Distribution for 24-hour General Storm for Southwest Region

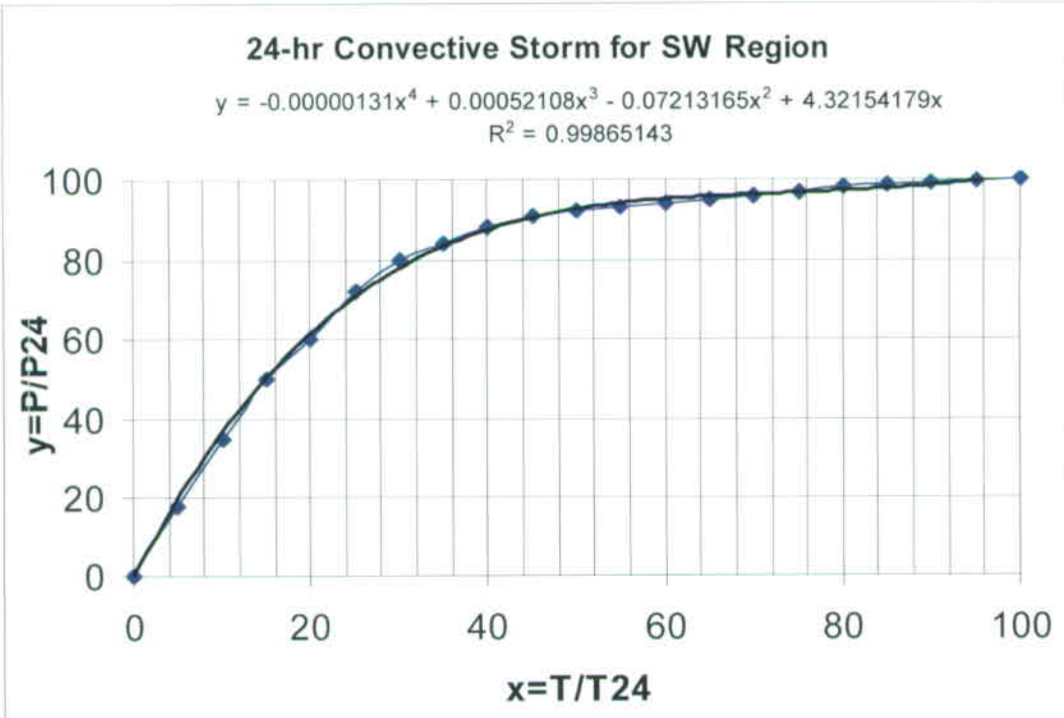

Figure 3 - Temporal Distribution for 24-hour Convective Storm for Southwest Region

2.3 Depth Area Reduction Factor

When analyzing rainfall-runoff response to a watershed, engineers are concerned with the average depth of precipitation over the entire area rather than at a particular point. *Depth-area curves* were developed to meet this need. The *depth-area-reduction-factor (DARF) curve* is an attempt to relate point precipitation values to the average depth over the watershed area for the same duration and frequency. Generally, there are two types of depth-area relations. The first is the *storm-centered* relation; that is, the maximum precipitation occurring when the storm is centered on the area being studied. The second type is the *geographically fixed-area* relation where the area is fixed and the storm is either centered over it or is displaced so only a portion of the storm affects the area. Each type of depth-area relation will be applied to the appropriate data. Generally, the storm-centered relations are used for preparing estimates of probable maximum precipitation while the geographically fixed relations are used for studies of precipitation-frequency values for basins. In this study, a DARF curve as shown in Figure 4 and data in Table 2 was developed using observed events in the project area and design storm distributions recommended for the project area. This empirical curve was derived from inadequate data points from various storm events covering 100- to 500- square mile areas. Beyond 500 square miles, the curve was derived by following the tendency of the curvature. Applying the DARF in Table 2 to area of 1,000 square miles or larger involves uncertainty due to inadequate data.

Figure 4 - Precipitation Depth-Area-Reduction Factors (DARF)

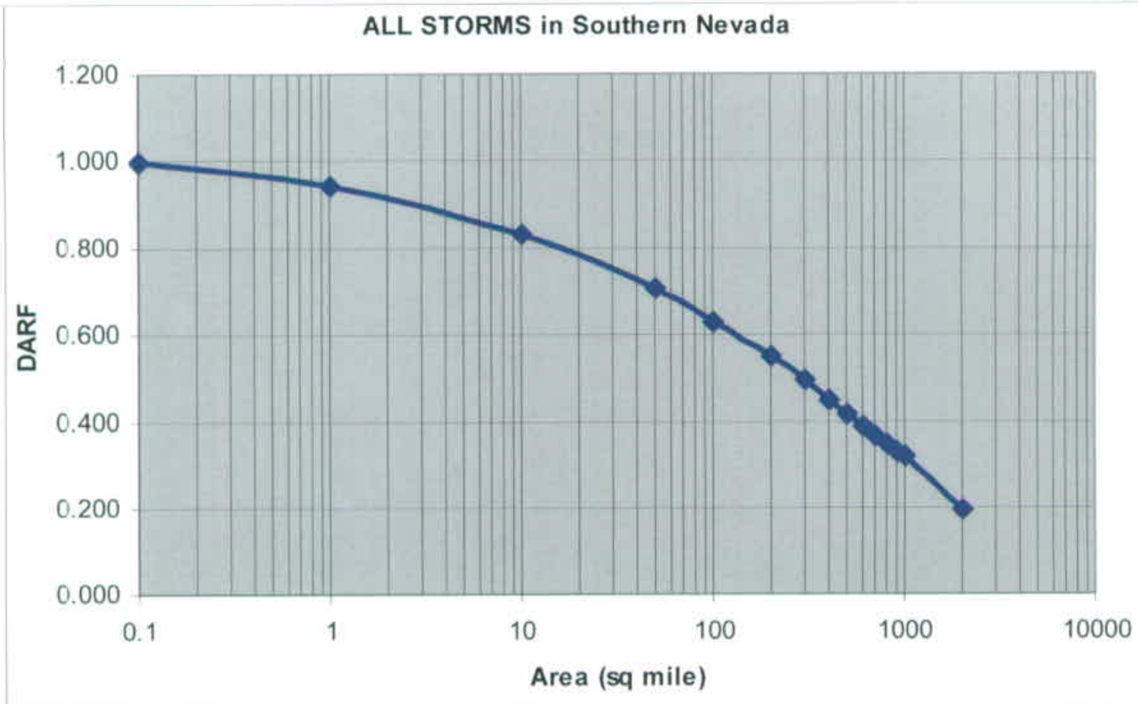

Table 2 - Depth Area Reduction Factors Developed for All Storms

Area sq miles	Observed						Recommended			Average
	8/10/1983	6/13/1955	8/10/1981	7/3/1975	10/21/1957	17-Oct	SPS	Hydro-6	Hydro-3	
	DARF									
0.1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**1.000**
1	0.97	0.92	0.96	0.95	0.90	0.95	0.95	0.96	0.93	**0.943**
10	0.88	0.75	0.81	0.87	0.79	0.87	0.85	0.86	0.81	**0.832**
50	0.82	0.69	0.70	0.75	0.76	0.75	0.70	0.80	0.75	**0.710**
100	0.47	0.40	0.52	0.66	0.67	0.67	0.60	0.65	0.78	0.630
200		0.30								0.550
300										0.495
400										0.450
500			0.34	0.41		0.50	0.48			**0.420**
600			0.30							0.390
700				0.30						0.370
800										0.350
900										0.330
1,000										0.320
2,000										0.200

3. DESIGN EVENTS

Design of the MRC will follow standards of the transportation industry as compiled by the following institutions:

1 American Railway Engineering and Maintenance-of-Way Association (AREMA)
2 American Association of State and Highway and Transportation Officials (AASHTO)
3 Federal Highway Administration (FHWA)
4 Nevada Department of Transportation (NDOT)

According to these references, the 50-year flood frequency is often used for evaluating the hydrologic reliability of rural transportation corridors. Other flood frequencies important in the design of transportation corridors include the 100-year frequency in accordance with the National Flood Insurance Program (NFIP) and the 500-year frequency for bridges that are vulnerable scour. In addition, arid region stream morphology is associated with more frequent floods in the range of the 10-year flooding event while the zero flow condition is usually associated with the 2-year storm event. Therefore, the hydrologic study for the MRC project will include 2-, 10-, 50-, 100-year flows. In this preliminary study, the 100-year event was selected as the base flood event to calibrate the hydrologic model using the existing drainage crossings under US95. The full spectrum flood flow predictions will be conducted during the design phase of the MRC project.

4. FLOOD FREQUENCY ANALYSIS AT STREAM GAGE

Determination of reliable peak runoff flow rates requires the use of various methods to provide the most accurate estimate of the peak flow events. For this project, it was planned to apply the flood frequency analysis, where available and applicable, to provide the best estimates of peak runoff values for the design of the MRC drainage facilities. Flood frequency is aimed at severe and extreme events. A reliable statistical analysis requires a continuous record of 10-years or longer. Reviews of USGS stream gage records in southern Nevada show a history of numerous years of dry bed conditions or nearly zero stream flows. Storms of all sizes, including severe storms, may produce a small quantity of runoff. For instance, the stream gage on Amargosa Wash at the Town of Beatty has a record of 16 years, including 8 years of nearly zero flow. In 1969, the highest peak flood flow was observed to be 16,000 cfs and the second highest was 4,220 cfs, recorded in 1967. The remaining years had peak flows less than 400 cfs. This case is typical for this region of the US. Such a discontinuity of stream flows fails the basic data requirement to produce reliable statistical predictions. Therefore, in this study, no further investigation was directed to statistical analysis methods because of inadequate flood records.

5. HYDROLOGIC MODELING

In this study, the HEC-1 hydrological simulation model, developed by US Army Corps of Engineers was adopted to predict design rainfall and runoff. The primary input parameters are discussed as follows:

(A) Precipitation Types
The project site is divided into the general and convective precipitation areas as delineated by NOAA Atlas 14, Volume 1. The maximum precipitation events in the general precipitation area are dominated by cold season precipitation cases while the maximum precipitation events in the convective precipitation area occur as warm storms. In general, the Beatty and Amargosa Washes tributary areas are subject to convective storms. The general type of precipitation dominates the Goldfield area and north of the Town of Tonopah.

(B) Design Rainfall Distribution
According to the NOAA Atlas 14, Volume 1, two 24-hr rainfall distribution curves were developed in this study for the general and convective types of storm. The 24-hour precipitation depth is weighted by area based on the isopluvials of rainfall depth.

(C) Depth Area Reduction Factors (DARF)
This study reviewed six storm area-distributions observed in southern Nevada and three standard storm spatial distributions recommend by the National Weather Service. As shown previously in Figure 4 and Table 2, a curve of rainfall DARF was derived in this study to cover the storm cover areas from 0.1 to 2,000 square miles.

(D) Design Events
The 100-year event is recommended as the base flood by the Federal Emergency Management Agency (FEMA) and used for flood insurance programs. Therefore, it is suggested that the watershed simulation model for this study be established and calibrated for the 100-year event.

(E) Hydrologic Loss
This study adopts the SCS curve numbers to estimate the hydrologic loss. It is recommended that a curve number of 85 (CN=85 – Herbaceous - mixture of grass, weeds, and low growing brush, with brush the minor element in a good hydrologic condition) under soil antecedent moisture condition II (AMCII) be used to predict *wash flows* in the Beatty area, and a curve number of 77 (CN=77 – Desert shrub – major plants include saltbush, greasewood, blackbrush, bursage, palo verde, mesquite, and cactus) be used to model the *pool flows* through the inland basins in the Goldfield and Tonopah areas. The shallow pool in the inland basin counts for storm water detention and on-site disposal as well. In this study, such on-site disposal was modeled as an additional hydrologic loss that can be numerically represented by a lower curve number, CN=77.

(F) Unit Hydrograph Method
The SCS unit hydrograph method is adopted in this study. The watershed area and lag time are required parameters. The lag time was calculated by

$$T_{lag} = 20K_n(\frac{LL_c}{\sqrt{S}})^{0.33} \quad (1)$$

Where T_{lag} = lag time in hours,
S = waterway slope in feet/mile,
L_c = length to centroid of watershed in miles,
L = watershed length in miles, and
K_n = waterway roughness equal to 0.05 for natural desert wash.

(G) Runoff Routing Method

The runoff movement through a *well-defined wash* is simulated by the Kinematic Wave method. The Muskingum method is adapted to route *overland flows* of 6 inches over alluvial fan areas or *pool flows* at a depth of 12 inches through an inland basin.

The above procedure was adopted in this study to establish consistent hydrologic simulation models for watersheds in this region.

6. STUDY FOR MAJOR WASH CROSSINGS

During the field reconnaissance, the location and description of existing structures at drainage crossings under US 95 were identified. Hydrologic parameters and simulation results as well as comparisons and verifications are described in the following sections.

6.1 Beatty Wash Bridge

Beatty Wash crosses US 95 approximately five (5) miles north of the town of Beatty. USGS stream gage is installed on the upstream side the bridge, which was constructed as a double 10-foot by 8-foot concrete box culvert shown in Photo 1; water flows from east to west. Beatty Wash is one of the major tributaries to Amargosa River, which crosses US 95 about ten (10) miles north of the Beatty Wash crossing. A significant amount of sediment was deposited upstream of the bridge.

Photo 1 - Beatty Wash Bridge at US 95

6.1.1 Tributary Area and Hydrologic Parameters

The area tributary to Beatty Wash upstream of US 95 including the drainage area between US95 and the proposed MRC alignment, the design location/point, is approximately 96 square miles. The upper watershed consists of steep mountain valleys from which runoff switches to sheet flow upon reaching the alluvial fans. Based on review of the natural drainage network, the Beatty watershed was divided into seven sub-areas with hydrologic parameters described in Table 3. The physical layout was converted into a link-node system wherein a link represents the downstream reach and a node represents the outlet of a sub-area. A HEC-1 model was coupled with a GIS pre-processor and post-processor to automate generation of input data and output reports. Figure 5 shows the Beatty Wash watershed developed and defined using the GIS processing methods.

Table 3 - Hydrologic Parameters for Beatty Wash Watershed

Sub Area	Subarea ID	Area sq mile	Upst Elev ft	Dnst Elev ft	Length of Waterway mile	Length to Centroid mile	Waterway Slope percent	Waterway Slope ft/mile	Curve Number	Rough Kn	USBR Lag Time hours
Beatty	100.00	21.99	1,750.00	1,560.00	6.82	3.41	0.53	27.87	85.00	0.050	1.63
	101.00	21.66	1,800.00	1,400.00	5.49	2.75	1.38	72.83	85.00	0.050	1.21
	102.00	17.96	1,400.00	1,350.00	10.61	5.30	0.09	4.71	85.00	0.050	2.93
	103.00	16.22	1,600.00	1,250.00	7.20	3.60	0.92	48.63	85.00	0.050	1.54
	104.00	10.86	1,250.00	1,100.00	7.95	3.98	0.36	18.86	85.00	0.050	1.93
	105.00	3.19	1,350.00	1,100.00	4.64	2.32	1.02	53.88	85.00	0.050	1.13
	106.00	3.93	1,250.00	1,050.00	3.98	1.99	0.95	50.29	85.00	0.050	1.04
	Total	95.83									

6.1.2 Design Rainfall Distribution

The HEC-1 model requires a precipitation value for each sub-area. The 100-year, 24-hour rainfall depth isopluvials published in NOAA Atlas 14, Volume 1, was overlaid on the watershed sub-areas in GIS as displayed in Figure 6. By intersecting sub-area and isopluvial polygons, point precipitation depths were area weighted to produce values shown in Table 4 for the seven subareas. The Beatty Wash watershed is subject to convective storm types.

Table 4 - Spatial Distribution of 100-yr, 24-hr Rainfall Depth in Beatty Wash Watershed

Subarea ID	Area square miles	P-24 inches
100.0	21.99	4.40
101.0	21.66	4.19
102.0	17.96	4.15
103.0	16.22	3.35
104.0	10.86	2.94
105.0	3.19	2.77
106.0	3.93	2.63

As stated in Section 5.C, point rainfall depths are subject to depth-area reduction based on the distance between the sub-area centroid and point of interest. Using results displayed in Figure 1, design rainfall depths were adjusted and then the appropriate temporal rainfall distribution listed in Table 5 was applied.

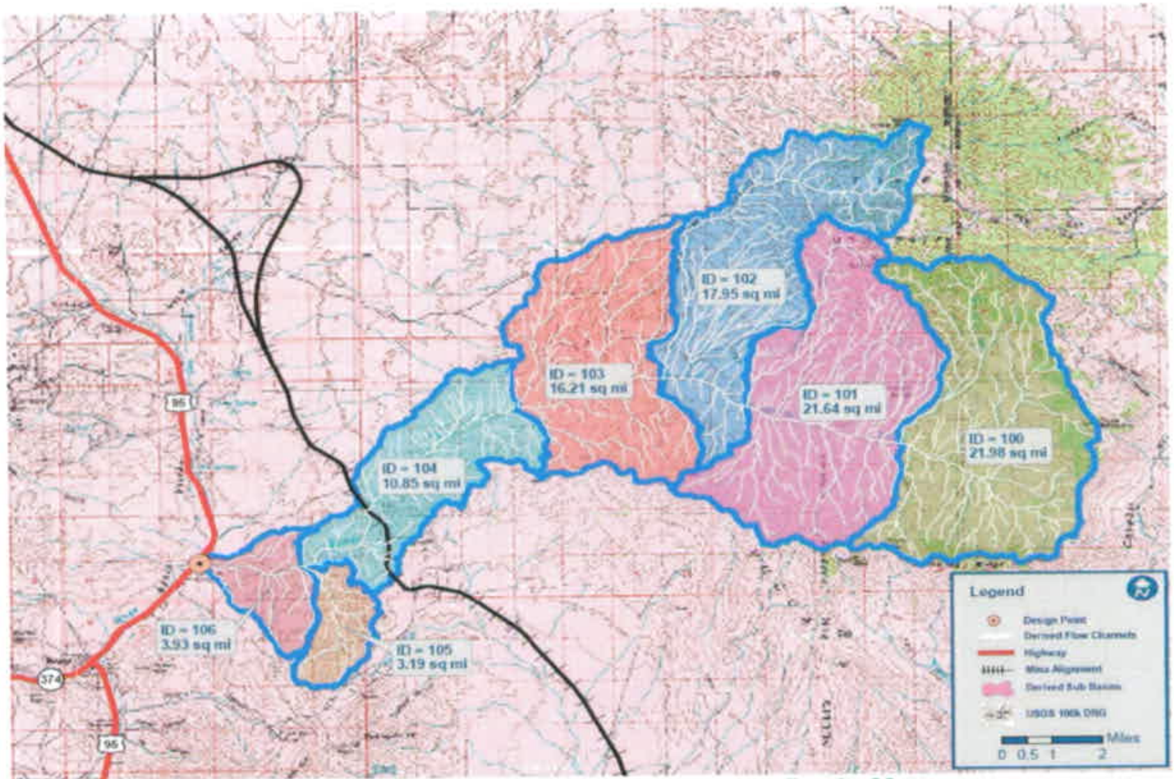

Figure 5 - Beatty Watershed Drainage Basin Map

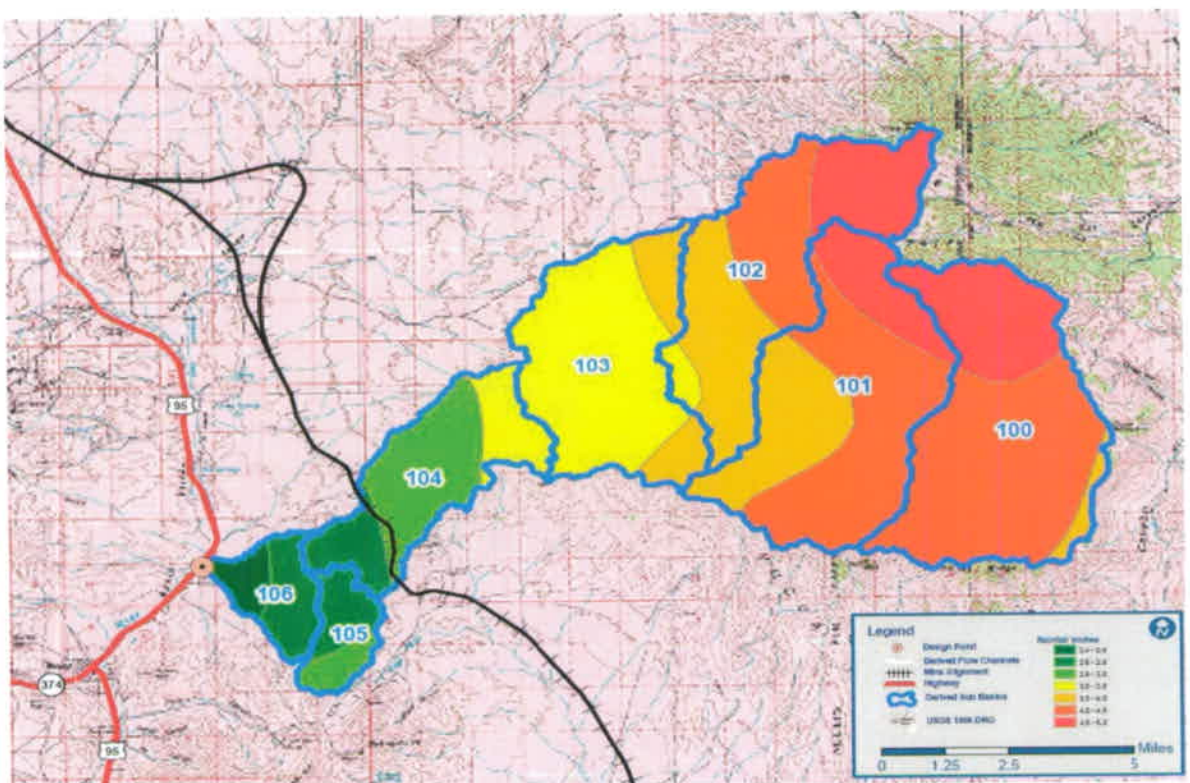

Figure 6 - Rainfall Distribution in Beatty Watershed

Table 5 - 24-hour Temporal Rainfall Distribution

T/Td	General Storm P/P24	Convective Storm P/P24
0	0	0
5	10	18
10	22	35
15	32	50
20	42	60
25	52	72
30	60	80
35	67	84
40	71	88
45	75	91
50	80	92
55	83	93
60	86	94
65	88	95
70	92	96
75	94	97
80	96	98
85	97	98.5
90	98	99
95	99	99.5
100	100	100

6.1.3 Hydrologic Loss

In the study watersheds, storm runoff begins at higher elevations and collects and is conveyed in the valley washes. At the mouth of the washes, runoff spreads over the alluvial fan surfaces and excess, if it exists, is collected in the eroded gullies or roadside ditches at the fan fringes as depicted in Photo 2. Existing data indicates that a significant portion of alluvial surface soils in Nevada consist of either surface rock features or buried caliche, both of which reduce the soil horizon's ability to infiltrate precipitation throughout the design storm events. Although the soils are not typically highly pervious, stormwater's journey from hilltop to valley floor and across alluvial fans presents numerous opportunities for hydrologic losses to occur. Common sources of hydrologic loss in the southwest region of the U.S. are listed below:

- Transmission loss in the fractured and eroded surface rock and soils,
- Evaportranspiration loss attributable to the arid climate and parched ground cover, and
- Infiltration loss in depressed areas or where pervious soils exist.

Photo 2 - Typical Stormwater Path in Watershed

When stormwater collects within a closed basin/inland basin, a shallow pond covering a large area typically results as shown in Photo 3. The stormwater in this natural shallow porous detention dissipates via soil infiltration and evaporation over an extended period of time.

Photo 3 - Typical Closed Basin

For this study, the 100-year event is modeled assuming Antecedent Moisture Condition II (AMC II) with an SCS Curve Number (CN) value of 85 to represent draining (wash flow) watersheds and a CN of 77 for interior-draining watersheds. Beatty Wash drains its watershed and therefore, a CN value of 85 is applicable.

6.1.4 Hydrograph Routing and Wash Network

In a HEC-1 model, a hydrograph is generated at a sub-area's outfall point based on the rainfall-runoff response of tributary area. Hydrographs combine at two outfall points and continue to another downstream point via a reach, which is given hydraulic parameters based on physical characteristics of the conveyance route. Hydrograph routing may attenuate peak flow and delay the time to peak based the method selected; therefore, care has to be taken when selecting the appropriate proper routing method. Based on the topographical information and the criteria discussed in Section 5.G, Muskingum method was selected to perform flood flow routing. Table 6 presents the Muskingum parameters for reach routing used in the Beatty Wash simulation.

Table 6 - Muskingum Parameters for Beatty Wash Watershed Reaches

Reach	Length	Slope	Rough	Depth	Velocity	K	X	N	Low limit	K/(N*dT)	Hi limit
ID	ft	ft/ft	Kn	ft	fps	hour			1/(2(1-X)	< and <	1/2X
100	22,000.0	0.0073	0.050	0.50	1.60	3.83	0.10	12.00	0.56	3.83	5.00
101	12,500.0	0.0040	0.050	0.50	1.18	2.93	0.10	12.00	0.56	2.93	5.00
102	22,000.0	0.0045	0.050	0.50	1.26	4.84	0.10	20.00	0.56	2.90	5.00
103	42,000.0	0.0036	0.050	0.50	1.12	10.42	0.10	40.00	0.56	3.13	5.00
104	15,500.0	0.0032	0.050	0.50	1.06	4.05	0.10	20.00	0.56	2.43	5.00

Where Kn = Roughness
K = Muskingum storage time constant in hour
X = Muskingum weighting factor
N = Time steps

6.1.5 Comparison

During the site visit to Beatty Wash at US 95, a water mark was observed on the stream gage housing approximately 7.5 feet above natural ground. Estimating an invert slope of 0.01 feet/feet through the double 10-foot by 8-foot concrete box culvert and a Manning's roughness value of 0.014 to represent the concrete invert, a normal depth calculation results in a capacity of approximately 4,773 cfs flowing 8 feet deep. The information described in Sections 6.1.1 through 6.1.4 was input into a HEC-1 model, which generated a 100-year peak flowrate of 4,698 cfs in Beatty Wash at this location (Appendix II – HEC-1 Output for Beatty Wash Watershed). This is a remarkably close comparison between modeled and estimated flowrates at the Beatty Wash crossing at US 95, however, additional hydraulic modeling is required before this correlation can be validated.

6.2 Amargosa River Bridge

The Amargosa River is a well-defined, natural waterway flowing east to west when it crosses US 95 near Bailey's Hot Springs 10 miles north of Beatty Wash. Photo 3 shows the existing bridge with total spans approximately 140 feet and one set of piers in the center. The embankments are well armored with boulders and cobbles on 2H: 1V side slopes. To offset an upstream approach angle of about 70 degrees, a long, curved training dike exists along the outer bank to guide stream flow into the bridge opening. Downstream of US 95, Amargosa River meanders until it parallels US 95 and then flows south toward the Beatty Wash confluence. Significant sediment deposits were not found under the bridge during the site visit, however, a water mark approximately 4.5 feet above the river bed was observed on the bridge pier.

Photo 3 - Amargosa River Bridge at US 95

6.2.1 Tributary Area and Hydrologic Parameters

The area tributary to Amargosa River at US 95 including the tributary area between MRC and US 95 covers about 297 square miles and was divided into six sub-areas with two reaches. The surface slope of the watershed varies from 22 feet per mile in the high areas to 8 feet per mile in lowland areas. The 100-year, 24-hour precipitation depths vary from 3.4 inches to 2.9 inches based on the isopluvials published in NOAA Atlas 14, Volume 1. The Amargosa watershed is influenced by convective storm types. No significant interior basin or valley storage volume features were indicated on USGS maps nor noted during the field visit. Therefore, surface runoff was subject to a CN 85 loss parameter and routed through the watershed as overland flows. Table 7 presents the hydrologic parameters for Amargosa sub-areas, Table 8 provides the Muskingum routing parameters and Figure 7 shows the watershed map.

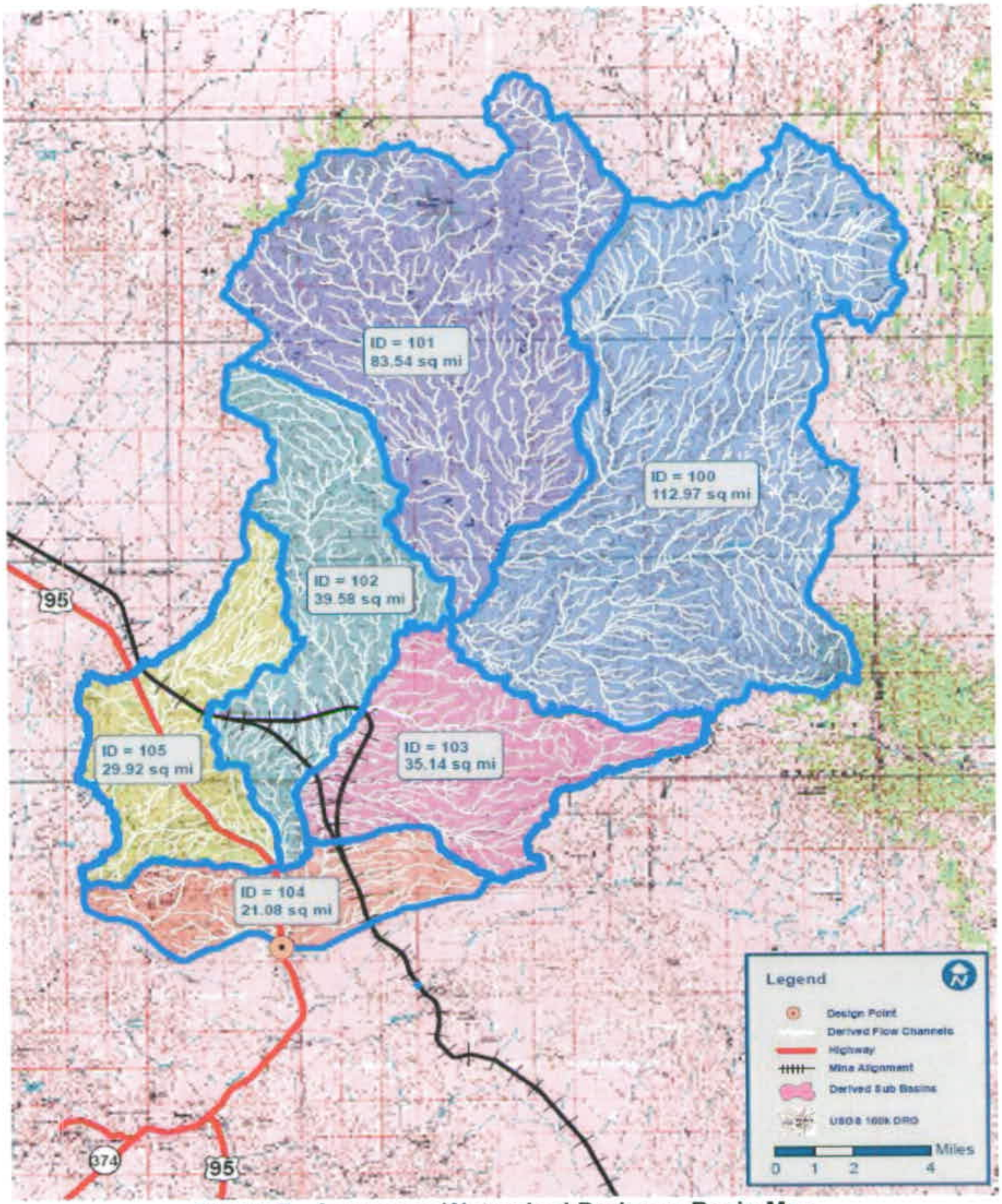

Figure 7 - Amargosa Watershed Drainage Basin Map

Table 7 - Hydrologic Parameters for Amargosa River Watershed

Subarea ID	Area (sq mi)	U/S Elev (ft)	D/S Elev (ft)	Waterway Length (mi)	Length to Centroid (mi)	Waterway Slope (%)	Waterway Slope (ft/mi)	CN	Rough Kn	USBR TLag (hr)
100.0	113.33	1,900.0	1,350.0	21.78	10.89	0.48	25.25	85.0	0.05	3.57
101.0	83.33	1,800.0	1,350.0	16.86	8.43	0.51	26.70	85.0	0.05	2.99
102.0	42.42	1,700.0	1,150.0	18.56	6.06	0.56	29.63	85.0	0.05	2.72
103.0	32.36	1,750.0	1,150.0	18.18	9.09	0.63	33.00	85.0	0.05	3.03
104.0	14.97	1,500.0	1,150.0	12.69	6.34	0.52	27.58	85.0	0.05	2.46
105.0	10.55	1,400.0	1,100.0	7.95	3.98	0.71	37.71	85.0	0.05	1.72
Total	296.96									

Table 8 - Muskingum Parameters for Amargosa River Watershed Reaches

Reach ID	Length (ft)	Slope (ft/ft)	Rough Kn	Depth (ft)	Velocity (fps)	K (hr)	X	N	Low limit 1/(2(1-X)	K/(N*dT) < and <	Hi limit 1/2X
100	59000.0	0.0034	0.050	0.50	1.09	15.03	0.10	50.00	0.56	3.61	5.00
101	16000.0	0.0031	0.050	1.00	1.67	2.67	0.10	20.00	0.56	1.60	5.00

6.2.2 Design rainfall Distribution

Figure 8 shows the spatial distribution of the 100-year, 24-hour rainfall depth isopluvials in Amargosa watershed tributary to US 95. Point precipitation values were determined in the same way as done for Beatty Wash watershed and are given in Table 9 for Amargosa River watershed.

Table 9 - Spatial Distribution of 100-yr, 24-hr Rainfall Depth in Amargosa Watershed

Subarea ID	Area (mi2)	P-24 (in)
100.0	113.33	3.43
101.0	83.33	3.89
102.0	42.42	3.10
103.0	32.36	3.84
104.0	14.97	2.89
105.0	10.55	2.89

6.2.3 Comparison

Using the parameters provided for Amargosa watershed and procedure applied to Beatty Wash watershed, the 100-year peak flood flow was predicted to be 10,077 cfs (Appendix III – HEC-1 Output for Amargosa River Watershed). By comparison, with an invert slope of 0.01 ft/ft under the bridge and a Manning's roughness value of 0.014, a flowrate of 10,382 cfs passes through the 140 feet wide bridge opening at a water depth of 4.5 feet based on normal depth calculations.

There are 16 years of records from a USGS gage station (Appendix IV/Gage number 10251220) located on Amargosa River downstream of the Beatty/Amargosa confluence. During this time period, a peak flowrate of 16,000 cfs was recorded. If the estimated peak flowrates from both Beatty and Amargosa watersheds are added arithmetically (15,465 cfs), they approximate the recorded peak. However, the HEC-1 model of the 100-year, 24-hour storm event attenuates the combined flowrate by 30% to 10,149 cfs. The location of a stream gage downstream of the Beatty/Amargosa confluence provides a reference for comparing flowrates from the two major drainage areas, however, with such a short time span, the records are unreliable for establishing flood event frequency.

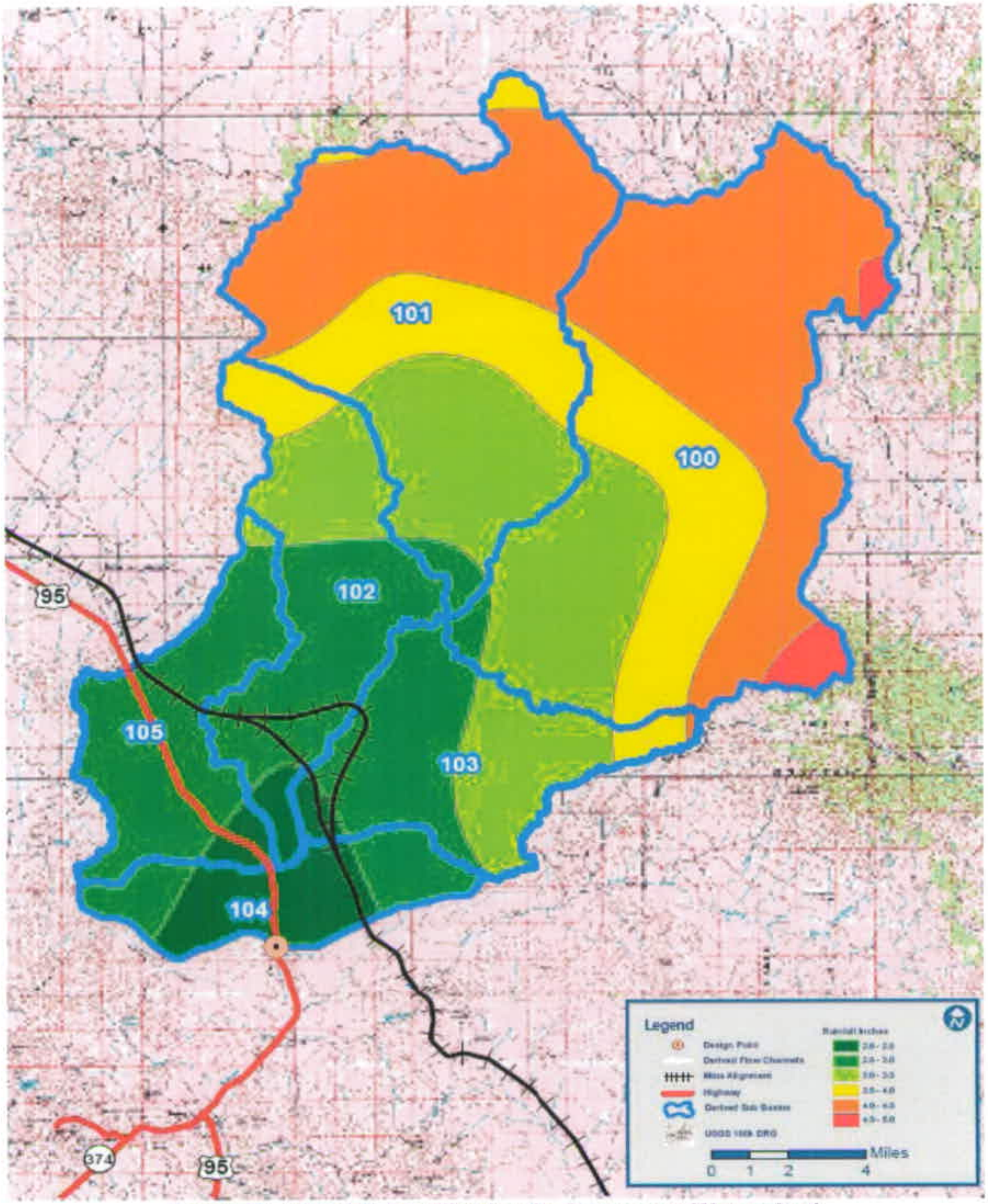

Figure 8 - Rainfall Distribution in Amargosa Watershed

6.3 General Crossings

Tolicha Wash crosses US 95 about 30 miles north of Beatty. The existing structure shown in Photo 4 is a double 10 feet by 8 feet concrete box culvert similar to the Beatty Wash structure. Runoff flows from east to west in Tolicha Wash, however, neither sediment deposits nor water marks were observed near the crossing structure. Upstream, the wash is shallow, wide, and not well-defined. Sparse shrubs and vegetation typical of the surrounding landscape were growing in the wash bed and along the banks, therefore, it has been some time since major flows have reached the culverts from the 223-square mile Tolicha Wash watershed. Without indication of significant wash flows or a stream gage station on Tolicha Wash, it is ineffectual to correlate modeled flowrates to normal depth estimates.

Photo 4 - Tolicha Wash Bridge at US 95

North of Tolicha Wash, crossing structures begin to gradually reduce in size. Jackson Wash crosses US 95 just south of Lida Junction (US 95 / SH 266) through double 10-foot by 5-foot concrete box culverts shown in Photo 5. There is evidence that flood water has reached Jackson Wash culverts and there are sediment deposits in the low areas. The tributary area as shown on Figure 9, to this culvert at Jackson Wash at US 95 is approximately 364 square miles and 100-year, 24-hour rainfall depths range from 2.93 to 3.4 inches (Figure 10) produced by general type storms. A large portion of the watershed is flat with depressed areas in which ponding may occur. Because of available storage in the watershed, a CN value of 77 was used in the HEC-1 model to represent hydrologic losses.

The HEC-1 model generates a 100-year peak runoff value of 2,740 cfs in Jackson Wash at US 95 (Appendix V – HEC-1 Output for Jackson Wash Watershed). Again, assuming a 0.01 feet/feet slope and Manning's n value of 0.014 for the concrete invert, Jackson Wash culverts can pass 2,463 cfs according to a normal depth calculation.

Photo 5 - Jackson Wash Culverts at US 95

In the eight (8) miles between Jackson Wash and China Wash, flow direction changes and trends from west to east. Also along this reach of US 95, dual 5-foot diameter corrugated metal pipes (CMPs) are located south of China Wash (Photo 6) that drain toward Stonewall Flat, an interior basin on the east side of the highway. Evidence of flowing water and pond imprints were observed upstream of the CMPs. On the downstream side, culvert inverts are suspended about two feet above the ground.

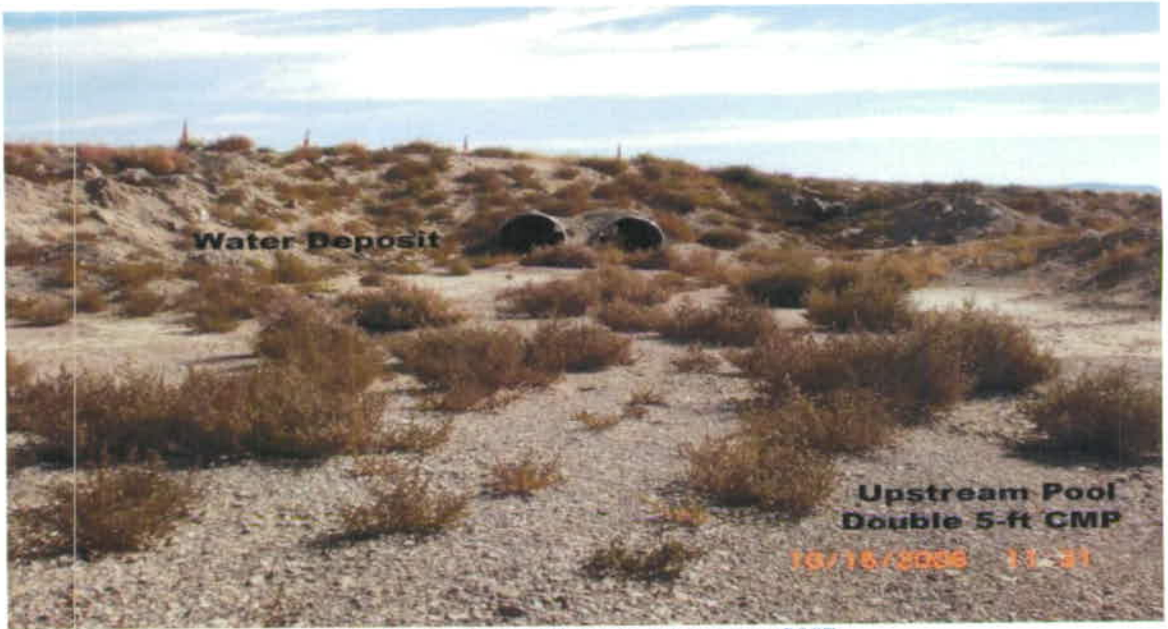

Photo 6 - Dual 60-inch diameter CMP

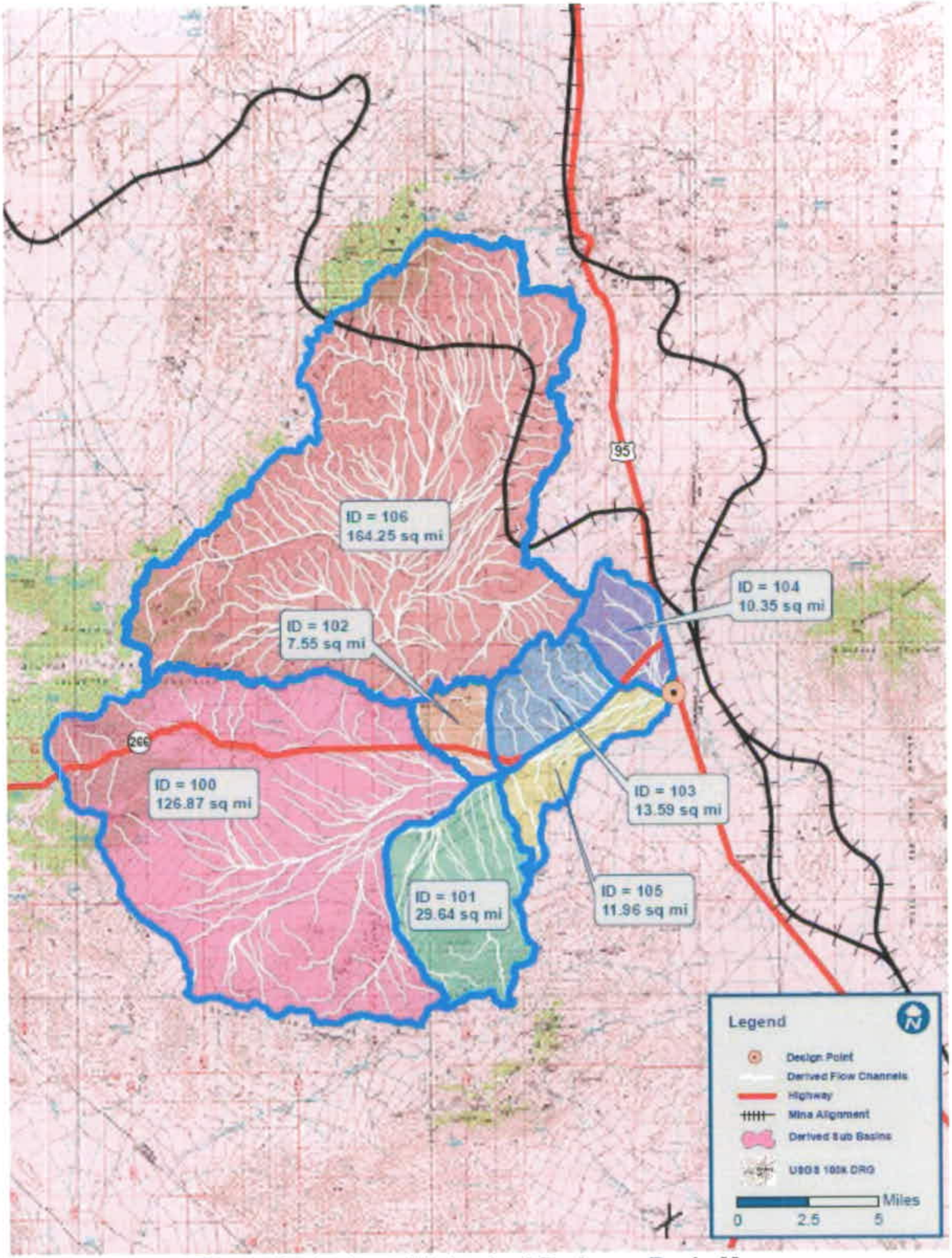

Figure 9 - Jackson Watershed Drainage Basin Map

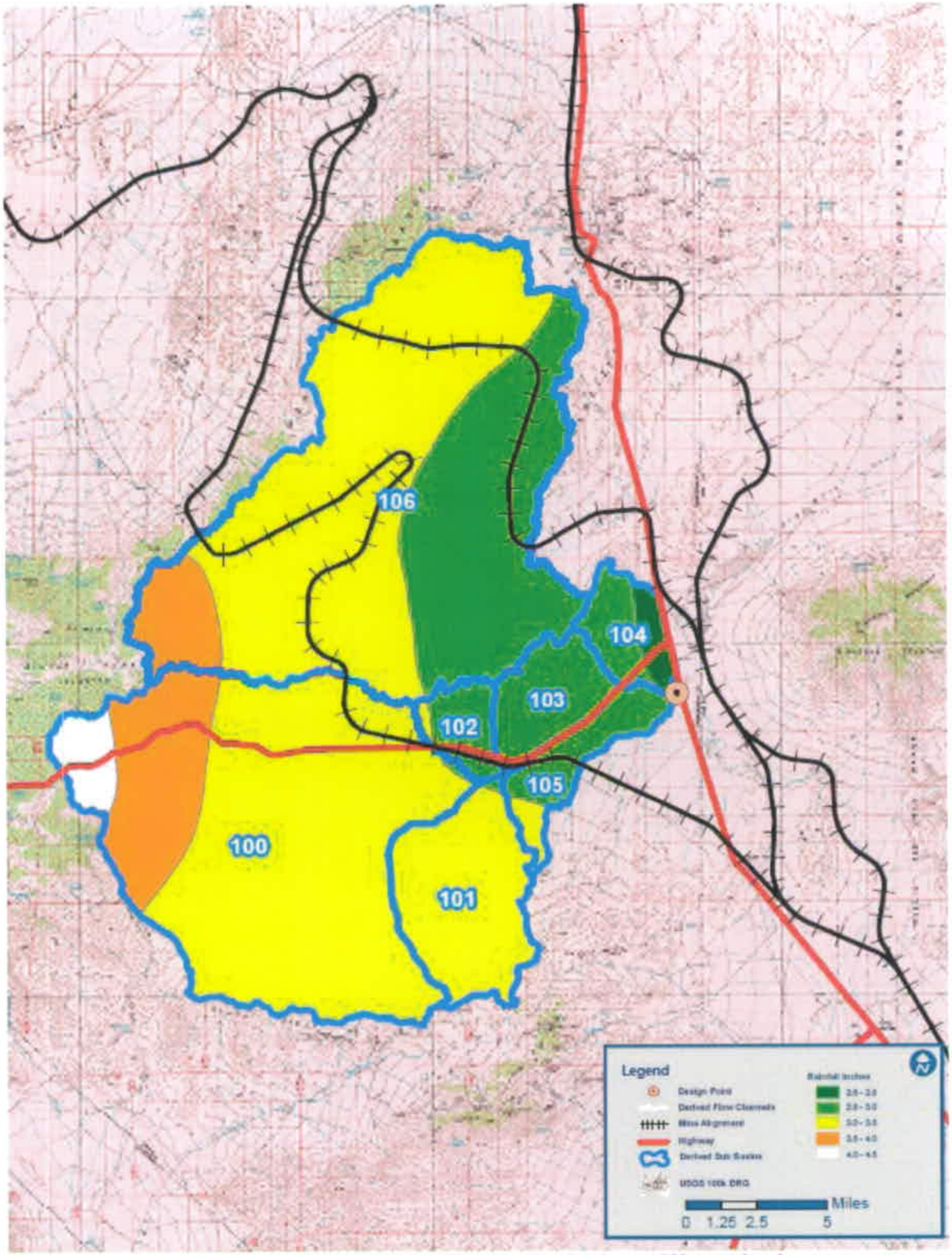

Figure 10 - Rainfall Distribution in Jackson Watershed

6.4 Equalizer Crossings

Between Goldfield and Tonopah, US 95 goes through the bottom of two dry lake beds, Alkali Lake and Mud Lake. Stormwater collects in these low areas and dissipates (infiltrates and evaporates). During the field trip, the team found several 24-inch diameter CMPs under US 95 along this reach. From a hydraulic perspective, these 24-inch diameter CMPs appear to function as equalizers to balance the water surface elevation on the both sides of US 95. The 24-inch diameter crossings are classified as "Equalizer Crossings" (Appendix VI) for this study.

Photo 7 - Stormwater and Sediment Deposit in Dry Lake Bed

6.5 Walker Lake Drainage Basin

The northwest end of the proposed MRC was extended approximately from Hawthorne to Schurz, through the Walker Lake drainage basin. Walker Lake is one of the few perennial, natural terminal lakes in the Nevada area Great Basin. Terminal lakes are a result of surface-water drainage in topographically closed basins. Under natural conditions, evaporation from the lake surface is typically the primary component of basin outflow. Due to high evaporation rates in the Great Basin, the water-levels and salinity of terminal lakes are extremely sensitive to changes in streamflow. Most streamflow in the Walker River Basin originates as snowmelt from the Sierra Nevadas. Prior to the late 1800s, most of the streamflow water flowed into Walker Lake. Since then, agricultural diversions have increased to the point that, except during flood flows; most streamflow is consumed by agriculture. The diversions have caused the level of Walker Lake to drop by 140 feet (42 meters) between 1882 and 1994.

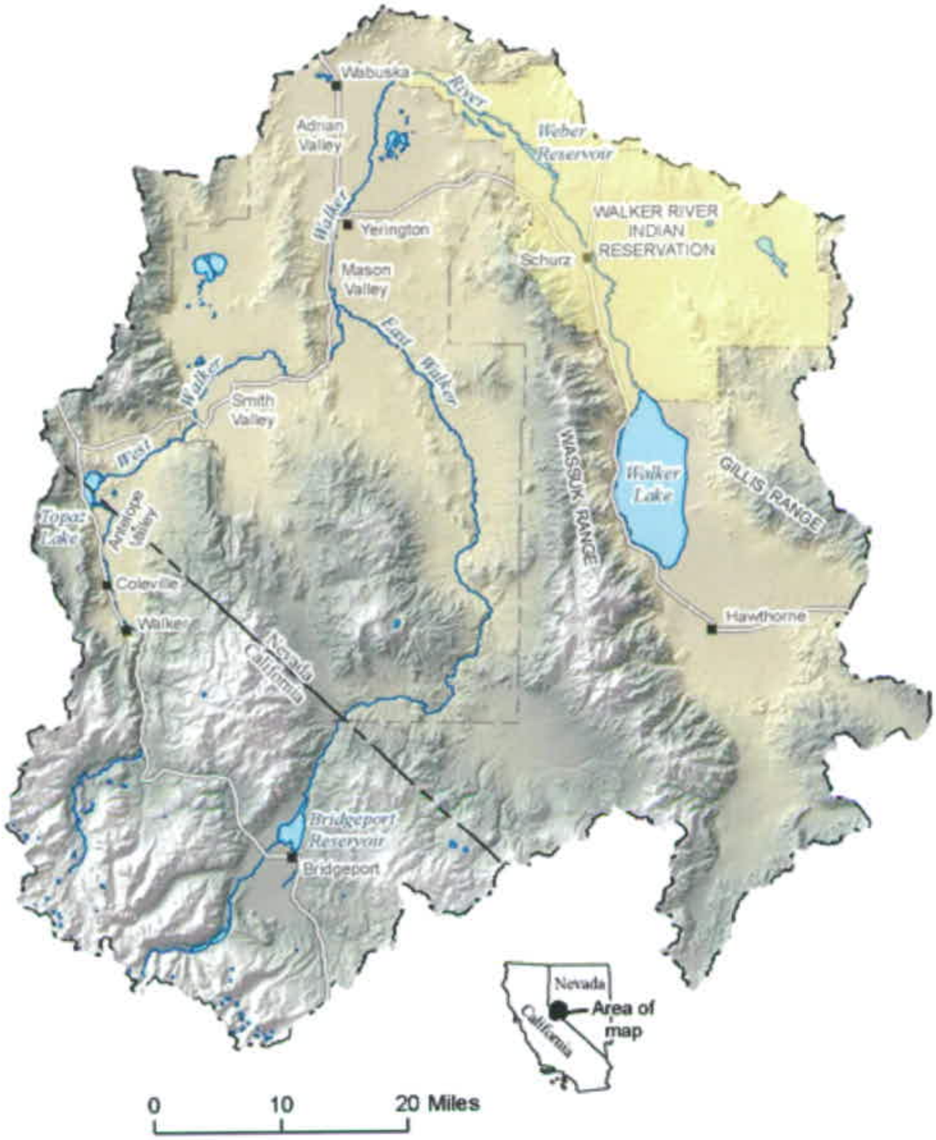

Figure 11 - Walker River Basin

The Walker River runs in west central Nevada. It is approximately 50 miles (80 km) long and drains an arid portion of the Great Basin southeast of Reno. The Walker River watershed extends into the Sierra Nevada Mountains. It flows within an enclosed basin, providing the principal inflow of Walker Lake. It is formed in southern Lyon County, 7 miles (11 km) south of Yerington, by the confluence of the East Walker and West Walker rivers, both of which descend from snowmelt in the Sierras along the California-Nevada border. It flows initially north past, Yerington into central Lyon County, where it turns sharply to the southeast, flowing through the Walker River Indian Reservation. It enters the northern end of Walker Lake along the east side of the Wassuk Range approximately 20 miles (32 km) NNW of Hawthorne though most the stream flow is consumed by irrigation before reaching Walker Lake.

Photo 8 - Walker Lake

6.5.1 East Walker River

The East Walker River is a tributary of the Walker River and is approximately 75 miles (121 kilometers) long and is located in eastern California and western Nevada. It drains part of the eastern side of the Sierra Nevada into the Walker Lake watershed in the Great Basin. The River rises from snowmelt in the Sierra Nevada Mountains in Nevada and eastern California, north of Mono Lake and near the northeast boundary of Yosemite National Park. It flows north through the Bridgeport Valley, past Bridgeport, where it is impounded to form the Bridgeport Reservoir. From there, It crosses into southern Lyon County, Nevada, passing through a canyon to emerge into the Mason Valley, a ranching region ultimately joining the West Walker River approximately 7 miles (13 kilometers) south of Yerington to form Walker River.

6.5.2 West Walker River

The West Walker River is a tributary of the Walker River and is approximately 75 miles (121 kilometers) long, located in eastern California and western Nevada. Like the East Walker River, it drains part of the Sierra Nevada range along the California-Nevada border in the watershed of Walker Lake in the Great Basin. It rises from snowmelt in the Sierras of northwestern Mono County, north of Yosemite National Park approximately 20 miles SSW of Walker. From there it flows north, along the west side of the Sweetwater Mountains, emerging into the Antelope Valley, a ranching region around Walker. It flows north past Coleville and Topaz and enters southern Douglas County in Nevada, southwest of Carson City. In this location, it flows northeast, joining the East Walker River from the west 7 miles (11.3 kilometers) south of Yerington to form the Walker River. The river is heavily used for irrigation in the ranching valleys along its lower course. Its waters are diverted along its upper course to form Topaz Lake along the California-Nevada border. It receives the Little Walker River from the south near its source in the mountains. In January 1997 a record-setting flood along the West Walker River destroyed 10 miles of U.S. 395. This section of road was rebuilt in 6 months. The silt carried by the river settled in Topaz Lake hurting the trout population there.

6.5.3 Little Walker River

The Little Walker River is a tributary of the West Walker River and is approximately 15 miles (24 kilometers) long, located in eastern California. It drains part of the Sierra Nevada Mountains in the watershed of Walker Lake. It rises from snowmelt in northwestern Mono County, north of Yosemite National Park in the Toyabie National Forest. It flows north, joining the West Walker River form the south, approximately 10 miles (16 kilometers) south of Walker.

6.5.4 Tributary Area and Hydrologic Parameters

Most of the tributary areas to the Walker River system are within the coverage of the general precipitation type of storm. Due to high elevation, the 24-hour precipitation values within the Walker Lake tributary area vary from 4.5 to 6.5 inches. Flood water is originated from steep valleys and then spread onto flat, wide alluvial plains. Therefore, high infiltration and depression losses are expected. As recommended (Clark County Hydrologic Design Criteria Manual 1995), the SCS curve number of 74 was used for 100-year storm water computer simulation. Muskingum routing scheme is applied to predict the flood wave movement through the flat and wide floodplains.

The selection of the sample watersheds for computer simulation studies was a challenge since most of USGS stream gages have a tributary area of 100 square miles or larger. There are a total of 19 USGS stream gages operating along the Walker River system. Nine of these 19 stream gages are located within the State of California. In this study, five sample watersheds, as shown in Table 10, were selected and Table 11 provides the routing parameters used for the hydrological analyses as well as for multiple regression analyses. Figures 12 to 16 show the watershed maps for each of the sample watersheds and provide drainage basin IDs and tributary areas.

Table 10 - Hydrologic Parameters for Sample Watershed

Sample Watershed	Subarea ID	Area (sq mi)	Waterway Length (mi)	Length to Centroid (mi)	CN	Rough Kn	USBR TLag (hr)
Chiatovich	100	12.59	4.00	2.00	74.0	0.05	0.86
	101	8.04	3.26	1.60	74.0	0.05	0.74
	102	3.14	2.70	1.35	74.0	0.05	0.66
	Total	23.77					
Reese	100	5.66	3.50	1.75	74.0	0.05	0.79
	101	3.79	3.00	1.50	74.0	0.05	0.71
	102	3.29	3.00	1.50	74.0	0.05	0.71
	Total	12.74					
Desert	100	14.92	6.50	3.25	74.0	0.05	1.19
	101	6.52	7.00	3.50	74.0	0.05	1.25
	102	10.59	5.50	2.75	74.0	0.05	1.06
	103	14.46	5.30	2.65	74.0	0.05	1.04
	Total	46.49					
Hoye Bridge	100	181.20	18.50	9.25	74.0	0.05	2.37
	101	93.22	10.00	5.00	74.0	0.05	1.58
	102	184.18	16.00	8.00	74.0	0.05	2.15
	103	61.02	9.00	4.50	74.0	0.05	1.47
	Total	519.62					
Sweetwater	100	181.18	20.00	10.00	74.0	0.05	2.49
	101	158.08	21.00	10.50	74.0	0.05	2.57
	102	131.17	12.00	6.00	74.0	0.05	1.78
	Total	470.43					

Table 11 - Muskingum Parameters for Sample Watershed Reaches

Sample Watershed	Reach ID	Length (ft)	Rough Kn	K (hr)	X	N	Low limit 1/(2(1-X)	K/(N*dT) < and <	Hi limit 1/2X
Chiatovich	100	16,896	0.050	1.45	0.10	5.0	0.56	3.47	5.00
	101	14,256	0.050	1.22	0.10	5.0	0.56	2.93	5.00
Reese	100	15,480	0.050	1.36	0.10	5.0	0.56	3.26	5.00
	101	15,480	0.050	1.36	0.10	5.0	0.56	3.26	5.00
Desert	100	36,960	0.050	3.16	0.10	5.0	0.56	7.60	5.00
	101	10,560	0.050	0.90	0.10	5.0	0.56	2.17	5.00
	102	27,984	0.050	2.40	0.10	8.0	0.56	3.59	5.00
Hoye Bridge	100	52,800	0.050	4.52	0.10	15.0	0.56	3.62	5.00
	101	84,480	0.050	7.23	0.10	25.0	0.56	3.47	5.00
	102	10,560	0.050	0.90	0.10	3.0	0.56	3.62	5.00
Sweetwater	100	63,360	0.050	5.43	0.10	20.0	0.56	3.26	5.00

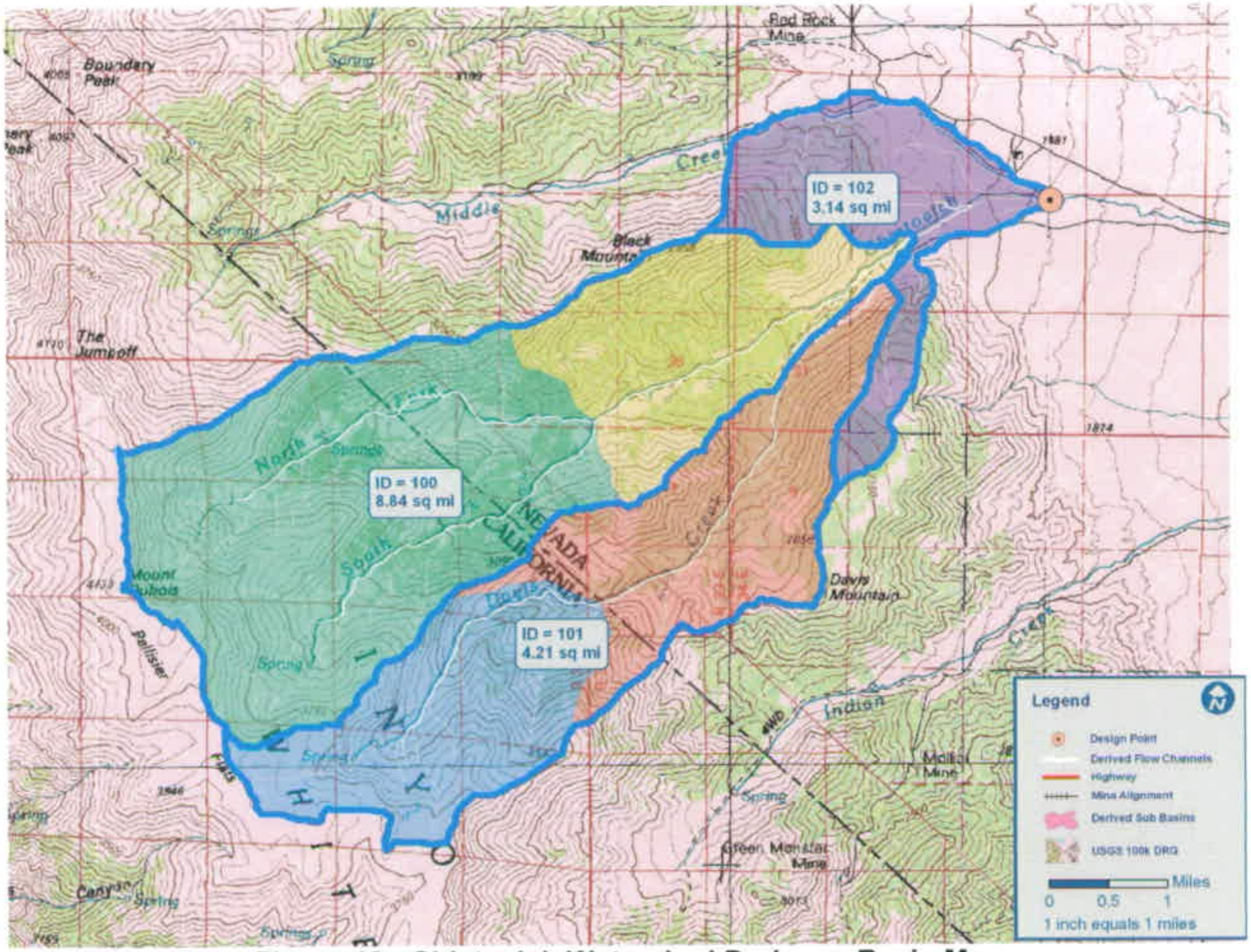

Figure 12 - Chiatovich Watershed Drainage Basin Map

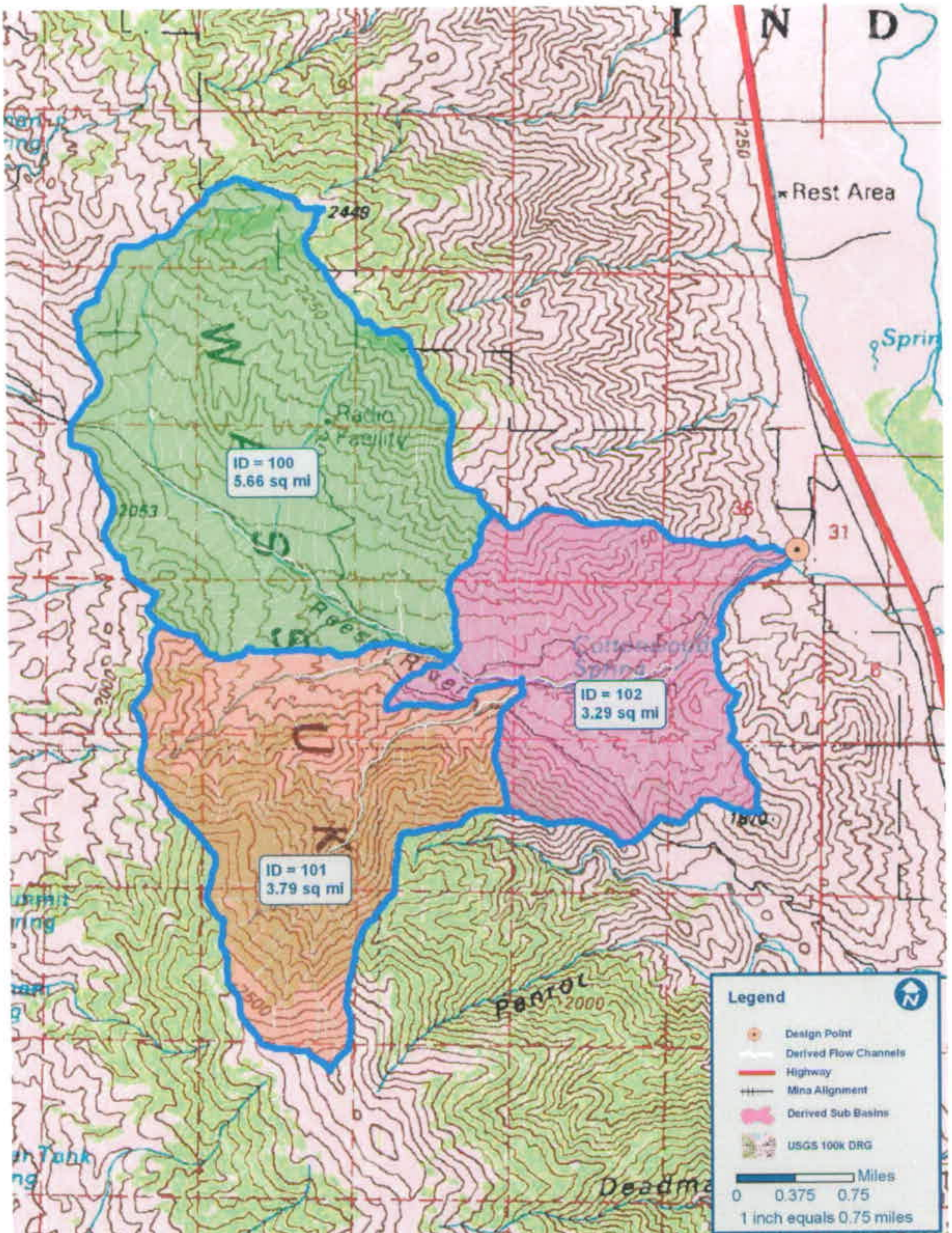

Figure 13 - Reese Watershed Drainage Basin Map

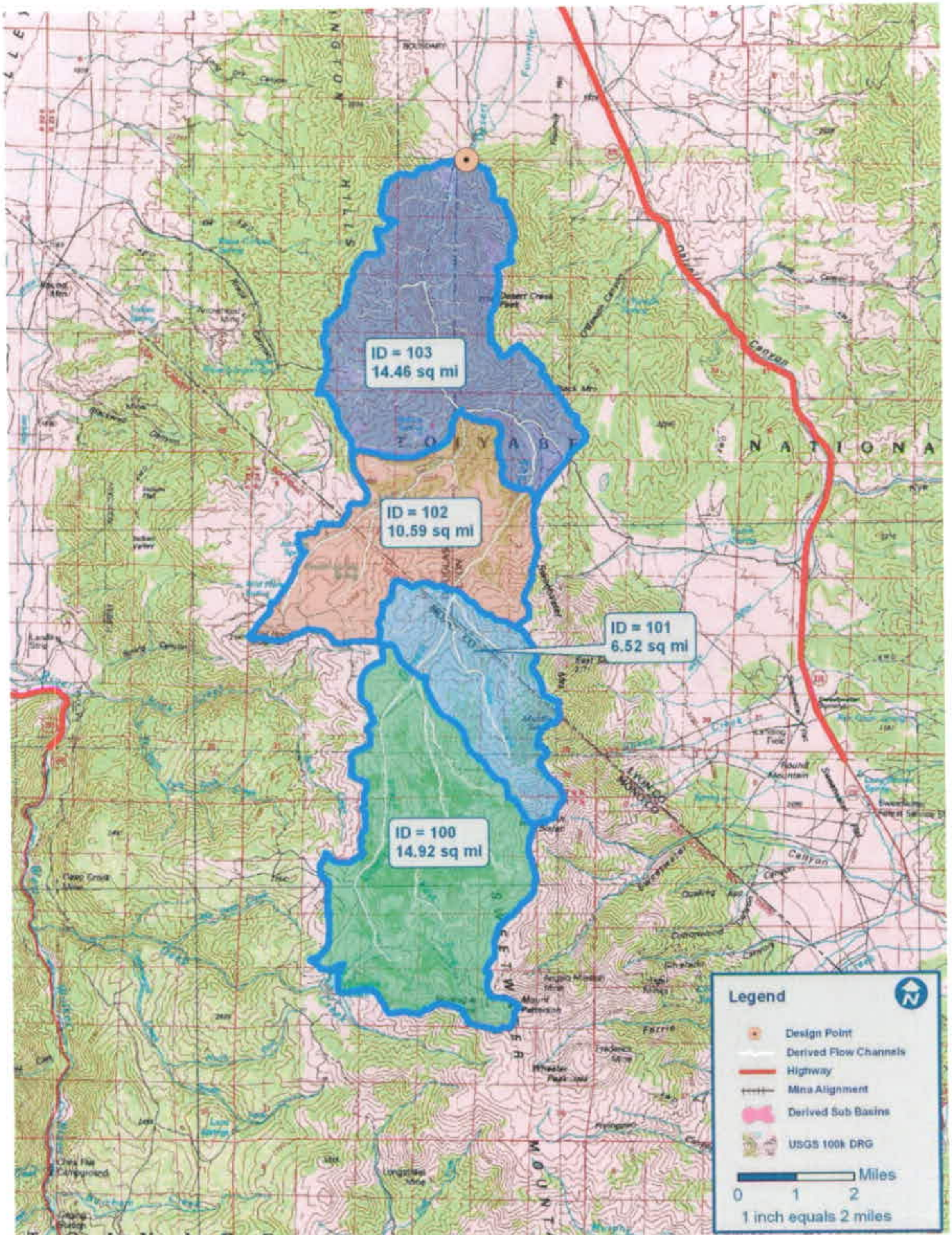

Figure 14 - Desert Creek Watershed Drainage Basin Map

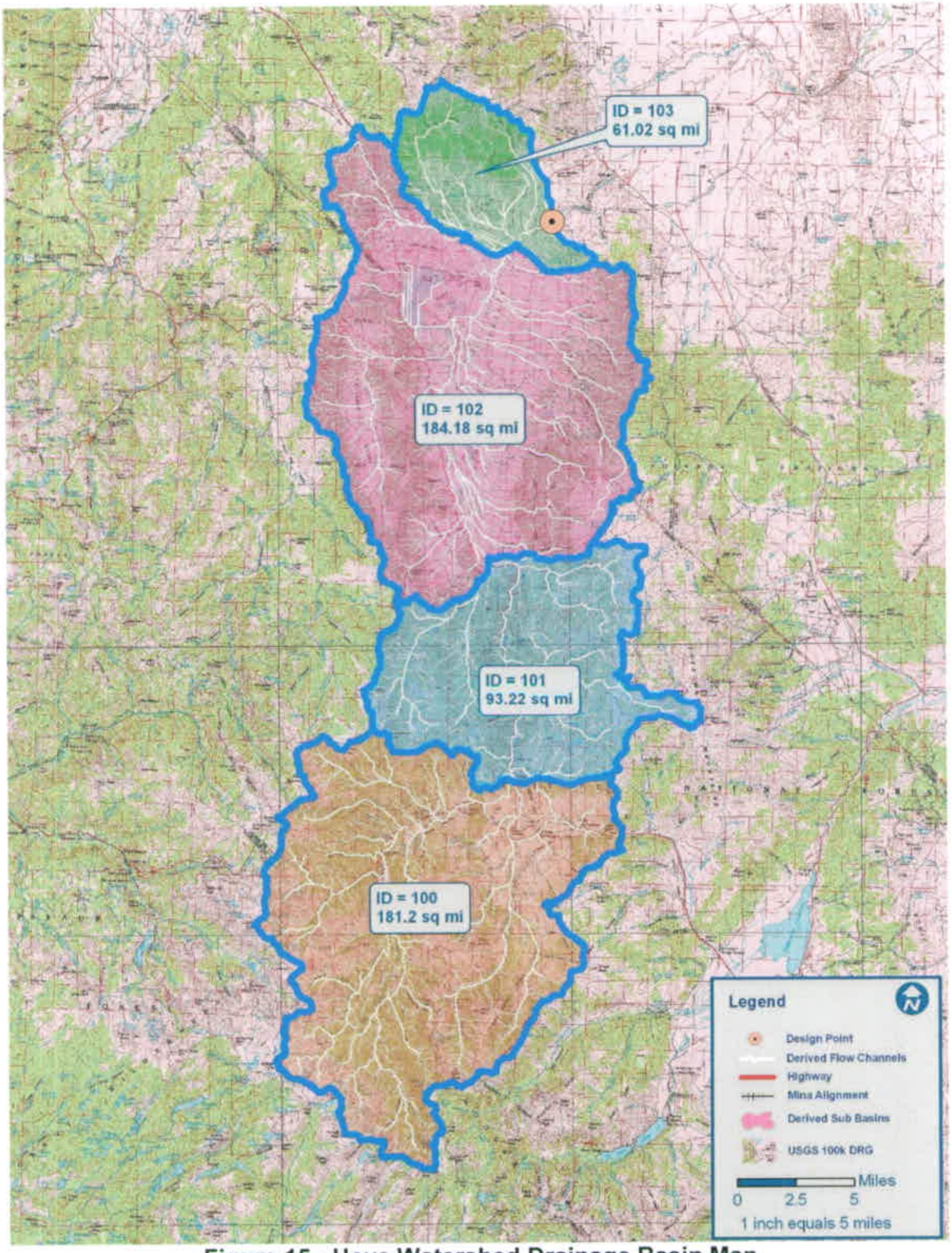

Figure 15 - Hoye Watershed Drainage Basin Map

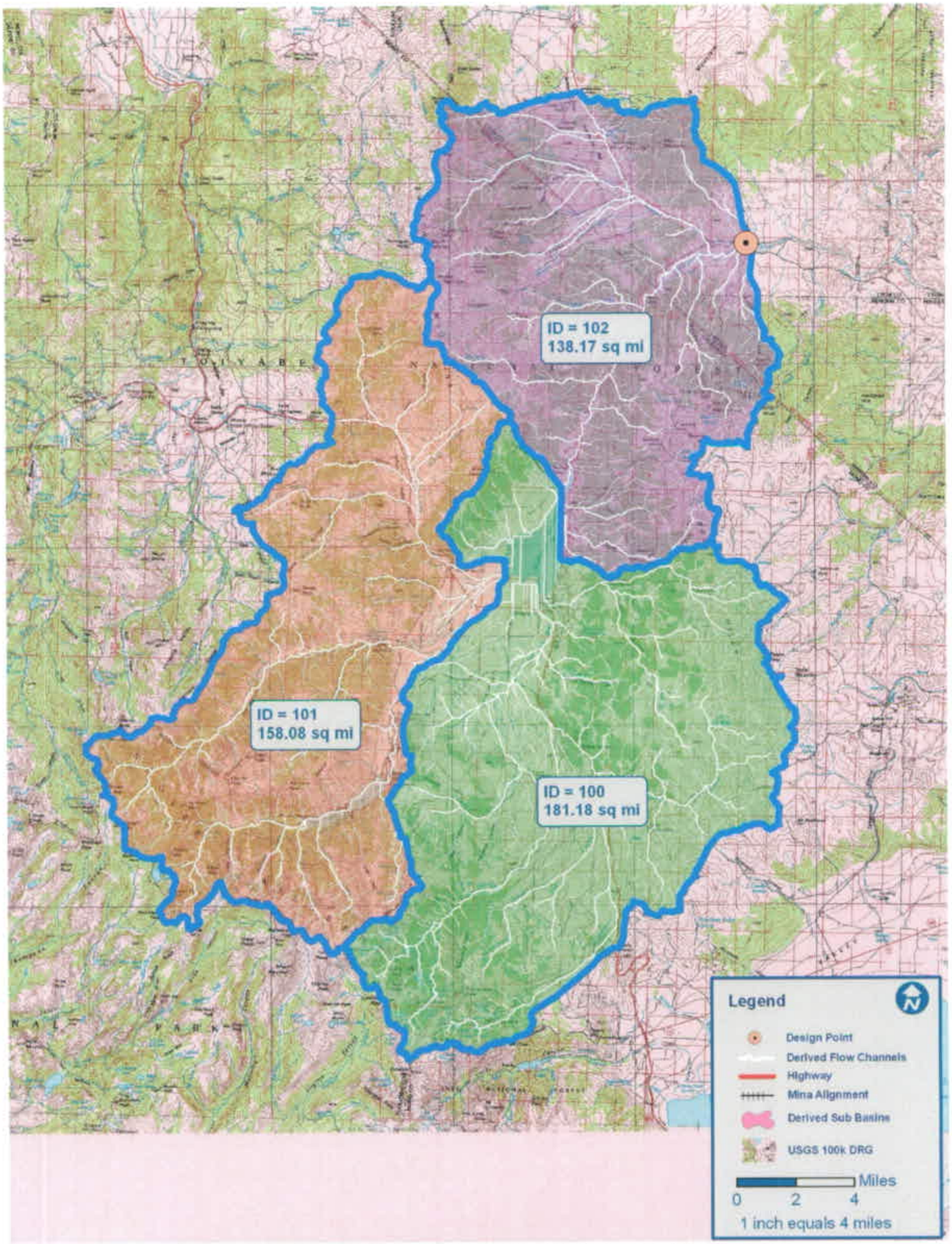

Figure 16 - Sweetwater Watershed Drainage Basin Map

6.5.5 Design rainfall Distribution

Table 12 shows the spatial distribution of the 100-year, 24-hour rainfall depth isopluvials in the five sample watersheds. Point precipitation values were determined using the same methodology as stated previously in section 6.1.2.

Table 12 -Spatial Distribution of 100-yr, 24-hr Rainfall Depth in the Sample Watersheds

Sample Watershed	Subarea ID	Area (mi^2)	P-24 (in)
Chiatovich	100	12.59	5.50
	101	8.04	5.00
	102	3.14	4.25
Reese	100	5.66	5.00
	101	3.79	4.75
	102	3.29	3.75
Desert	100	14.92	6.50
	101	6.52	6.50
	102	10.59	6.25
	103	14.46	5.75
Hoye Bridge	100	181.20	6.50
	101	93.22	6.00
	102	184.18	4.00
	103	61.02	5.00
Sweetwater	100	181.18	5.00
	101	158.08	6.00
	102	131.17	4.00

6.5.6 Comparison

These five sample watersheds have a total of 24 confluence points through the wash drainage network. Therefore, 24 data sets of 100-year peak flood flow were produced by HEC-1 computer models and then used as the database to yield the regional regression equation for the 100-year peak flood flow.

The regression results were further compared with the prediction by frequency analyses using long-term records collected at the stream gages tabulated in Table 13.

Table 13 - Selected USGS Stream Gages

USGS Station Gage Number	Name	Location	Tributary Area (mi^2)
10297500	West Walker River	At Hoye Bridge Near Wellington	450
10299100	Desert Creek	Near Wellington	947
10300000	West Walker River	Near Hudson	50.4

In comparison, the regression results are more conservative in prediction than frequency analysis. The 100-year flood peak flow predicted by regression is approximately twice that of the frequency analysis. As expected, this discrepancy results from the common practices of flow diversion in the Walker Lake valleys for local irrigation and industrial needs. At USGS 10300000 Hudson gage station, the record is continuous from 1965 to 1979. Out of the 15 years of record, the highest peak flow was 265 cfs. In January 1997, an extreme event occurred to this 50.4-square mile watershed and produced a peak flow of 1,102 cfs.

Please Note: the regression equation format is similar to the regional equation derived for the area from Goldfield to Tonopah because both regions are subject to the same prevailing storm pattern – general storm type.

7. REGIONAL HYDROLOGIC ANALYSIS

As part of National Flood Frequency (NFF) program, the USGS developed and published regional flood prediction equations for the State of Nevada. As illustrated in Figure 16, the state is divided into six hydrologic regions. These regions were delineated on the basis of regional flood sources and elevation. A large portion of the project site is located in Region 6 and the empirical formula for Region 6 is shown below:

$$Q_{100} = 20000 A^{0.51} (H/1000)^{-2.3} \qquad \text{USGS NFF Study} \qquad (2)$$

Where, Q_{100} = 100-year peak flow in cfs,
A = tributary area in square miles,
H = mean watershed elevation in feet.

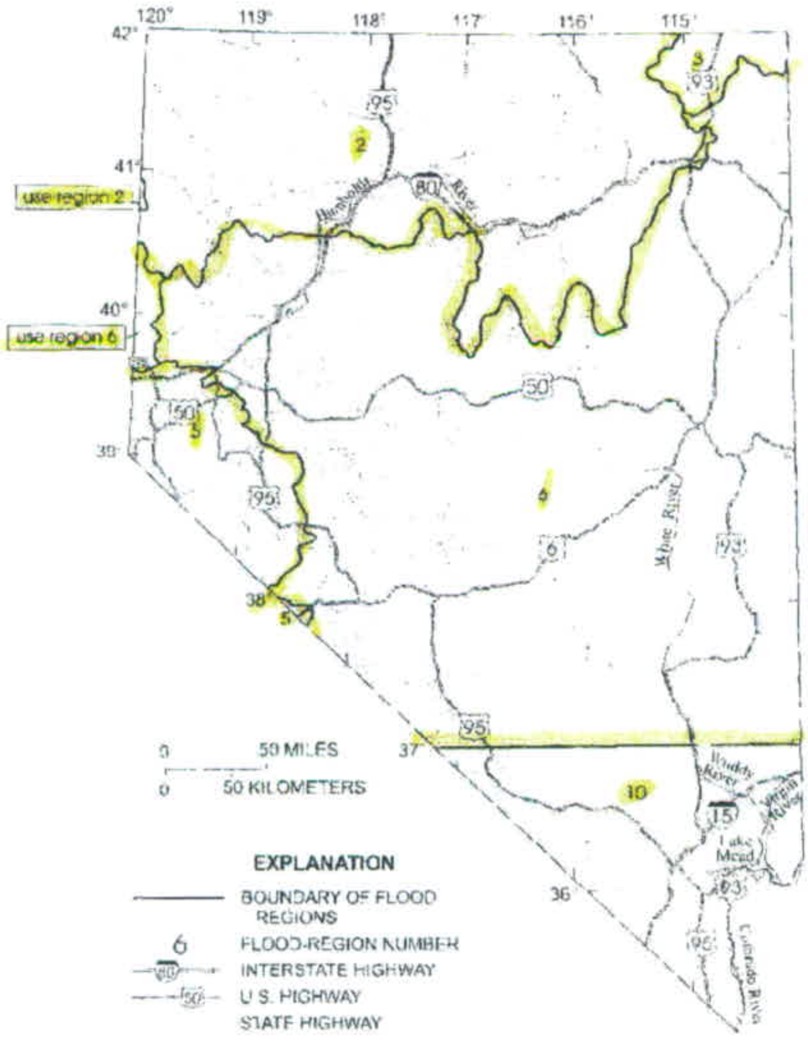

Figure 17 - Hydrologic Regions for Nevada (USGS)

In this report, multiple regression analyses were conducted for convective and general precipitation types of storms shown in Figure 17. The database consists of the HEC-1 predicted peak flows for various sizes of sub-areas, however, the maximum watershed area is less than 500 square miles. The empirical equations below have correlation coefficients of 0.99 and 0.96 for the Walker Lake area.

$$Q_{100} = 58.34A^{0.849}(Darf \times P_{24})^{1.052} \text{ for convective storm} \quad (3)$$

$$Q_{100} = 12.30A^{0.83}(Darf \times P_{24})^{1.88} \text{ for general storm} \quad (4)$$

$$Q_{100} = 11.89A^{0.915}(Darf \times P_{24})^{1.807} \text{ for general storm at Walker Lake area} \quad (5)$$

Where, P_{24} = point rainfall depth in inch at the design point,
DARF = depth area reduction factor defined by Figure 5.

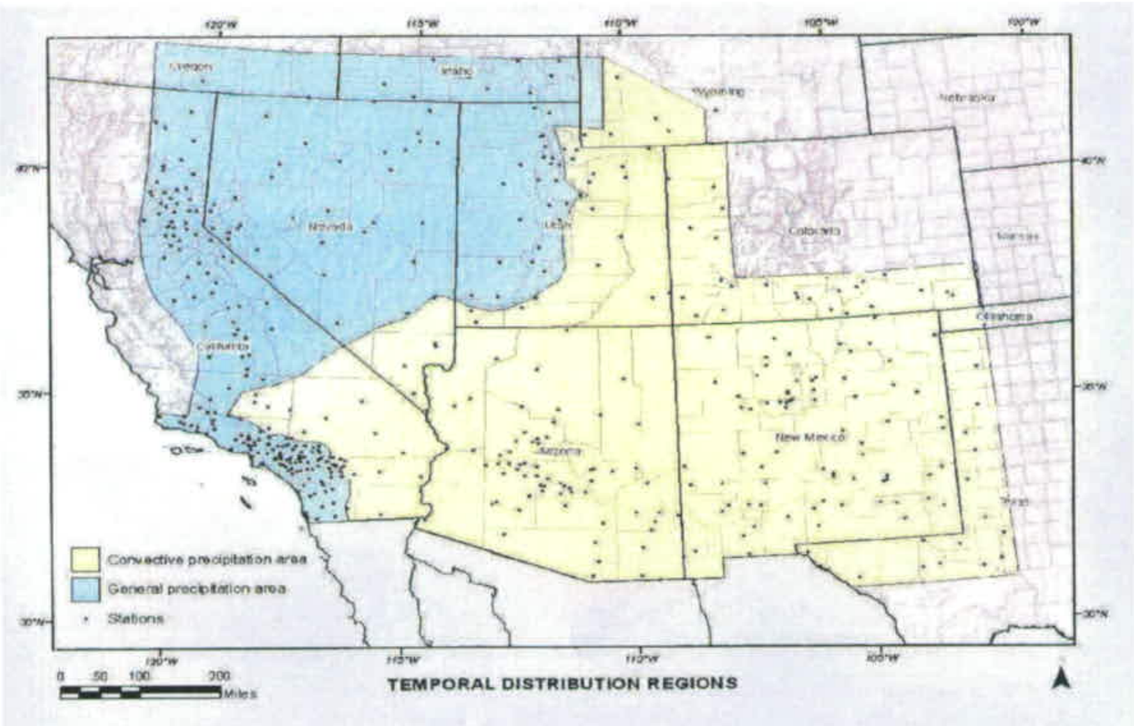

Figure 18 - Temporal Distribution of Storm Types in Southwestern US

Peak flows along the visited and studied US 95 corridor are dominated by *direct runoff* generated from drainage areas within 30 miles of the highway rather than *routed runoff* through alluvial fans or inland basins due to the losses that occur on those surfaces. Although Equations 3, 4 and 5 were derived from a limited database, they are useful for preliminary hydrologic estimations. However, for the rail corridor project, detailed hydrologic modeling will be completed based on physical watershed characteristics. Data collection tasks were carried out over a 6-week period to support future hydrologic modeling.

8. CONCLUSION

Based on information collected during the field investigation through out the project and computer modeling on various hydrologic conditions and types of storm, conclusions are listed as follows:

1. The south end of the MRC is influenced by a convective precipitation type of storm, whereas the north end of the MRC is influenced by general precipitation storms. The town of Beatty is located at approximately the dividing point between these storm types.

2. Between Beatty and Goldfield, drainage is dominated by shallow overland flows and wide wash flows. Based on using a CN value of 85 in the hydrologic model, major drainage structures under US 95 can pass the 100-year peak flood flow with an 8-foot high opening. This finding provides a suggestion for the low cord elevation for the proposed rail line.

3. From Goldfield to Tonopah, most of the watersheds contain large, shallow inland detention (dry lake beds). Storm runoff is conveyed to the low areas via washes and then ponds. It is recommended that a CN value of 77 be used to represent hydrologic losses in the HEC-1 computer model for these types of watersheds. The major crossings under US 95 along this corridor have a 5-foot high opening.

4. From Tonopah to Hawthorne, there is immense storage volume within the sub-areas. Hydrologically, these watersheds are closed systems that drain internally. During the site visit, several 24-inch diameter culverts were noted along US 95. They appear to function as equalizers to balance and transfer stormwater ponding on both sides of US 95. No large culverts or bridges were found under US 95 in this area.

5. North of Hawthorne to Walker Lake area, most of the watersheds contain large, shallow inland detention (dry lake beds), well-defined washes and many flow diversions in the flat valley areas. Storm runoff is conveyed to the low areas via washes and then ponds. It is recommended that a CN value of 74 be used to represent hydrologic losses in the HEC-1 computer model for these types of watersheds. The major crossings under US 95 along this corridor have 8 to 10-foot high openings.

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Appendix I: Hydrological Design Rainfall Parameters

Design By: JG
Check By: EH
Date: 11/14/06

FOUR TYPES OF RAINFALL DISTRIBUTION FROM NOAA ATLAS 14

96-hr General Precipitation

1st Quartile			Max
0	0	0	
25	63	63	
50	84	21	
75	95	11	
100	100	5	**63**
2nd Quartile			Max
0	0	0	
25	25	25	
50	78	53	
75	96	18	
100	100	4	53
3rd Quartile			Max
0	0	0	
25	19	19	
50	34	15	
75	90	56	
100	100	10	56
4th Quartile			Max
0	0	0	
25	20	20	
50	29	9	
75	48	19	
100	100	52	52

96-hr Convective Precipitation

1st Quartile			Max
0	0	0	
25	72	72	
50	93	21	
75	99	6	
100	100	1	**72**
2nd Quartile			Max
0	0	0	
25	25	25	
50	87	62	
75	99	12	
100	100	1	62
3rd Quartile			Max
0	0	0	
25	18	18	
50	32	14	
75	92	60	
100	100	8	60
4th Quartile			Max
0	0	0	
25	20	20	
50	29	9	
75	53	24	
100	100	47	47

24-hr General Precipitation

1st Quartile			Max
0	0	0	
25	52	52	
50	80	28	
75	94	14	
100	100	6	**52**
2nd Quartile			Max
0	0	0	
25	24	24	
50	68	44	
75	92	24	
100	100	8	44
3rd Quartile			Max
0	0	0	
25	15	15	
50	40	25	
75	80	40	
100	100	20	40
4th Quartile			Max
0	0	0	
25	20	20	
50	35	15	
75	58	23	
100	100	42	42

Design By: JG
Check By: EH
Date: 11/14/06

24-hr Convective Precipitation

1st Quartile			Max
0	0	0	
25	72	72	
50	92	20	
75	98	6	
100	100	2	**72**
2nd Quartile			Max
0	0	0	
25	24	24	
50	75	51	
75	95	20	
100	100	5	51
3rd Quartile			Max
0	0	0	
25	18	18	
50	38	20	
75	87	49	
100	100	13	49
4th Quartile			Max
0	0	0	
25	18	18	
50	30	12	
75	50	20	
100	100	50	50

6-hr General Precipitation

1st Quartile			Max
0	0	0	
25	50	50	
50	80	30	
75	94	14	
100	100	6	**50**
2nd Quartile			Max
0	0	0	
25	24	24	
50	60	36	
75	84	24	
100	100	16	36
3rd Quartile			Max
0	0	0	
25	19	19	
50	42	23	
75	75	33	
100	100	25	33
4th Quartile			Max
0	0	0	
25	20	20	
50	40	20	
75	63	23	
100	100	37	37

6-hr Convective Precipitation

1st Quartile			Max
0	0	0	
25	65	65	
50	93	28	
75	99	6	
100	100	1	**65**
2nd Quartile			Max
0	0	0	
25	25	25	
50	70	45	
75	92	22	
100	100	8	45
3rd Quartile			Max
0	0	0	
25	18	18	
50	40	22	
75	80	40	
100	100	20	40
4th Quartile			Max
0	0	0	
25	18	18	
50	35	17	
75	58	23	
100	100	42	42

Design By: JG
Check By: EH
Date: 11/14/06

SELECTION OF DESIGN RAINFALL DISTRIBUTIONS

96-hr General Precipitation

1st Quartile			Max
0	0	0	
25	63	63	
50	82	19	
75	96	14	
100	100	4	**63**

General Storm

T/96	P/P96
0	0
5	15
10	30
15	45
20	55
25	63
30	70
35	74
40	78
45	82
50	85
55	88
60	91
65	92
70	94
75	95
80	96
85	97
90	98
95	99
100	100

96-hr Convective Precipitation

1st Quartile			Max
0	0	0	
25	72	72	
50	93	21	
75	99	6	
100	100	1	**72**

Convective Storm

T/96	P/P96
0	0
5	22
10	40
15	55
20	65
25	72
30	80
35	84
40	88
45	91
50	93
55	95
60	96
65	97
70	98
75	99
80	99.2
85	99.4
90	99.6
95	99.8
100	100

24-hr General Precipitation

1st Quartile			Max
0	0	0	
25	52	52	
50	80	28	
75	94	14	
100	100	6	**52**

General Storm

T/24	P/P24
0	0
5	10
10	22
15	32
20	42
25	52
30	60
35	67
40	71
45	75
50	80
55	83
60	86
65	88
70	92
75	94
80	96
85	97
90	98
95	99
100	100

Design By: JG
Check By: EH
Date: 11/14/06

24-hr Convective Precipitation

1st Quartile			Max
0	0	0	
25	72	72	
50	92	20	
75	98	6	
100	100	2	**72**

Convective Storm

T/24	P/P24
0	0
5	18
10	35
15	50
20	60
25	72
30	80
35	84
40	88
45	91
50	92
55	93
60	94
65	95
70	96
75	97
80	98
85	98.5
90	99
95	99.5
100	100

6-hr General Precipitation

1st Quartile			Max
0	0	0	
25	50	50	
50	80	30	
75	94	14	
100	100	6	**50**

General Storm

T/6	P/P6
0	0
5	10
10	19
15	27
20	37
25	50
30	60
35	65
40	72
45	78
50	81
55	83
60	86
65	88
70	92
75	94
80	96
85	97
90	98
95	99
100	100

6-hr Convective Precipitation

1st Quartile			Max
0	0	0	
25	65	65	
50	93	28	
75	99	6	
100	100	1	**65**

Convective Storm

T/6	P/P6
0	0
5	13
10	28
15	38
20	50
25	65
30	73
35	82
40	88
45	92
50	93
55	95
60	96
65	97
70	98
75	99
80	99.2
85	99.4
90	99.6
95	99.8
100	100

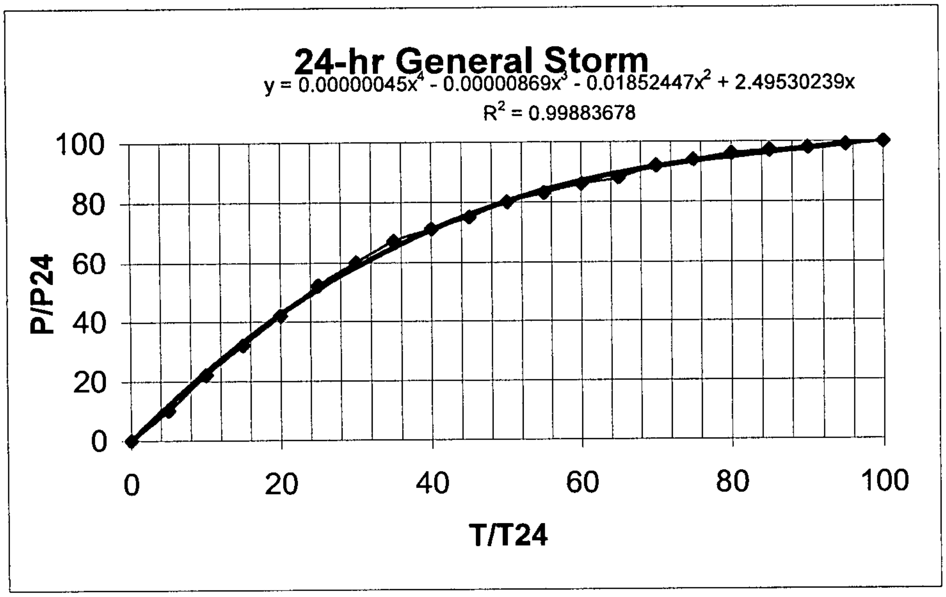
Design By: JG
Check By: EH
Date: 11/14/06

NEST STRUCTURE AMONG 6-, 24-, and 96-HR RAINFALL DISTRIBUTIOINS

P96= 2.78 inch | P24= 2.19 inch | P6= 1.51 inch

T/96	Hours	P/P96	96-hr Dp inch	24-hr Dp inch	Hours	24-hr Dp inch	6-hr Dp inch	Hours	Dp inch
0	0.0	0.0	0.0		0.0	0.0		0.0	0.0
5	4.8	15.0	0.4		1.2	0.22		0.3	0.2
10	9.6	30.0	0.83	0	2.4	0.48		0.6	0.29
15	14.4	45.0	1.25	0.92	3.6	0.70	0	0.9	0.41
20	19.2	55.0	1.53	1.55	4.8	0.92	0.56	1.2	0.56
25	24.0	63.0	1.75	1.88	6.0	1.14	1.09	1.5	0.76
30	28.8	70.0	1.95	2.10	7.2	1.31	1.30	1.8	0.91
35	33.6	74.0	2.06	2.19	8.4	1.47	1.45	2.1	0.98
40	38.4	78.0	2.17		9.6	1.55	1.51	2.4	1.09
45	43.2	82.0	2.28		10.8	1.64		2.7	1.18
50	48.0	85.0	2.36		12.0	1.75		3.0	1.22
55	52.8	88.0	2.45		13.2	1.82		3.3	1.25
60	57.6	91.0	2.53		14.4	1.88		3.6	1.30
65	62.4	92.0	2.56		15.6	1.93		3.9	1.33
70	67.2	94.0	2.61		16.8	2.01		4.2	1.39
75	72.0	95.0	2.64		18.0	2.06		4.5	1.42
80	76.8	96.0	2.67		19.2	2.10		4.8	1.45
85	81.6	97.0	2.70		20.4	2.12		5.1	1.46
90	86.4	98.0	2.72		21.6	2.15		5.4	1.48
95	91.2	99.0	2.75		22.8	2.17		5.7	1.49
100	96.0	100.0	2.78		24.0	2.19		6.0	1.51

Design By: JG
Check By: EH
Date: 11/14/06



T/Td	General P/P24	Cnvctive P/P24	General P/P6	Cnvctive P/P6	Prediction P/P6
0	0	0	0	**0.0**	**0.0**
5	10	18	10	**13.0**	**14.6**
10	22	35	19	**28.0**	**28.3**
15	32	50	27	**38.0**	**41.0**
20	42	60	37	**50.0**	**52.6**
25	52	72	50	**65.0**	**62.9**
30	60	80	60	**73.0**	**71.8**
35	67	84	65	**82.0**	**79.4**
40	71	88	72	**88.0**	**85.5**
45	75	91	78	**92.0**	**90.3**
50	80	92	81	**93.0**	**93.8**
55	83	93	83	**94.0**	**96.1**
60	86	94	86	**95.0**	**97.5**
65	88	95	88	**96.0**	**98.0**
70	92	96	92	**97.0**	**97.9**
75	94	97	94	**97.5**	**97.4**
80	96	98	96	**98.0**	**97.0**
85	97	98.5	97	**98.5**	**96.8**
90	98	99	98	**99.0**	**97.3**
95	99	99.5	99	**99.6**	**98.9**
100	100	100	100	**100.0**	**102.1**

Design By: JG
Check By: EH
Date: 11/14/06

100 YEARS

Equations for Design Rainfall Distributions with 5- minute Interval

Storm	a	b	c	d	e
24hr G	0.0000000000	0.0000004500	-0.0000086900	-0.0185244700	2.4953023900
24hr C	0.0000000000	-0.0000013100	0.0005210800	-0.0721316500	4.3215717900
6hr G	0.0000000000	0.0000021700	-0.0003754600	0.0061573600	1.9819049100
6hr C	0.0000000000	0.0000025174	-0.0003275828	-0.0120204499	2.9812473785

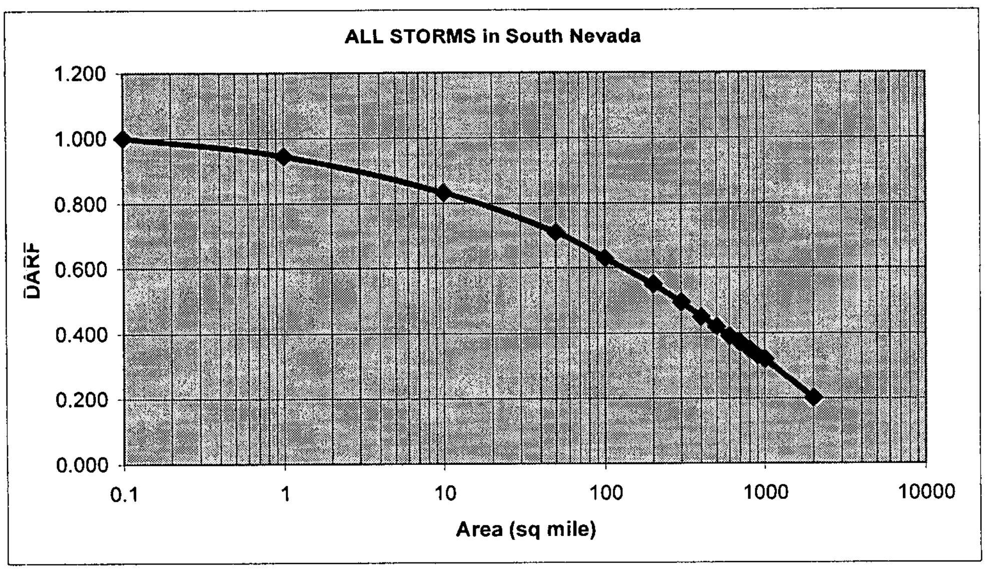
Time 5.0 minutes
Duration 720 minutes

Time Minutes	T/T6	General Math Model P/P6	General Design Curves	Convective Math Model P/P6	Convective Design Curve P/P6
0	0	0.0	**0.0**	0	**0.00**
5.0	1.39	2.8	**2.8**	4.12	**4.12**
10.0	2.78	5.5	**5.5**	8.18	**8.18**
15.0	4.17	8.3	**8.3**	12.19	**12.19**
20.0	5.56	11.1	**11.1**	16.14	**16.14**
25.0	6.94	13.9	**13.9**	20.02	**20.02**
30.0	8.33	16.7	**16.7**	23.83	**23.83**
35.0	9.72	19.5	**19.0**	27.57	**27.57**
40.0	11.11	22.3	**21.6**	31.23	**31.23**
45.0	12.50	25.1	**24.1**	34.81	**34.81**
50.0	13.89	27.8	**26.7**	38.30	**38.30**
55.0	15.28	30.5	**29.3**	41.71	**41.71**
60.0	16.67	33.2	**31.9**	45.03	**45.03**
65.0	18.06	35.8	**34.4**	48.25	**48.25**
70.0	19.44	38.4	**37.0**	51.38	**50.00**
75.0	20.83	41.0	**40.3**	54.40	**54.40**
80.0	22.22	43.5	**43.6**	57.33	**57.33**
85.0	23.61	46.0	**46.9**	60.16	**60.16**
90.0	25.00	48.4	**50.1**	62.88	**62.88**
95.0	26.39	50.7	**53.4**	65.50	**65.50**
100.0	27.78	53.0	**56.7**	68.01	**68.01**
105.0	29.17	55.3	**60.0**	70.42	**70.42**
110.0	30.56	57.5	**61.7**	72.72	**73.00**
115.0	31.94	59.6	**63.2**	74.91	**75.14**
120.0	33.33	61.7	**64.9**	76.99	**77.29**
125.0	34.72	63.7	**66.6**	78.97	**79.43**
130.0	36.11	65.6	**68.4**	80.84	**81.57**
135.0	37.50	67.5	**70.1**	82.60	**83.71**
140.0	38.89	69.3	**71.8**	84.25	**85.86**
145.0	40.28	71.0	**72.0**	85.80	**88.00**
150.0	41.67	72.6	**73.3**	87.24	**88.71**
155.0	43.06	74.2	**74.6**	88.58	**89.43**
160.0	44.44	75.8	**75.9**	89.82	**90.14**
165.0	45.83	77.2	**77.1**	90.96	**90.86**
170.0	47.22	78.6	**78.4**	92.00	**91.57**
175.0	48.61	79.9	**79.7**	92.94	**92.29**
180.0	50.00	81.1	**81.0**	93.80	**93.00**
185.0	51.39	82.3	**81.7**	94.56	**93.29**
190.0	52.78	83.4	**82.4**	95.23	**93.57**
195.0	54.17	84.4	**83.1**	95.83	**93.86**
200.0	55.56	85.4	**83.9**	96.34	**94.14**
205.0	56.94	86.3	**84.6**	96.77	**94.43**
210.0	58.33	87.2	**85.3**	97.13	**94.71**
215.0	59.72	88.0	**86.0**	97.42	**95.00**
220.0	61.11	88.7	**86.9**	97.64	**95.29**
225.0	62.50	89.4	**87.7**	97.81	**95.57**
230.0	63.89	90.0	**88.6**	97.92	**95.86**
235.0	65.28	90.6	**89.4**	97.98	**96.14**
240.0	66.67	91.1	**90.3**	97.99	**96.43**
245.0	68.06	91.6	**91.1**	97.96	**96.71**
250.0	69.44	92.1	**92.0**	97.90	**97.00**
255.0	70.83	92.5	**92.5**	97.81	**97.07**
260.0	72.22	92.9	**93.0**	97.70	**97.14**
265.0	73.61	93.2	**93.5**	97.57	**97.21**
270.0	75.00	93.5	**94.0**	97.43	**97.29**
275.0	76.39	93.9	**94.5**	97.29	**97.36**
280.0	77.78	94.2	**95.0**	97.15	**97.43**
285.0	79.17	94.4	**95.5**	97.03	**97.50**
290.0	80.56	94.7	**96.0**	96.92	**97.57**
295.0	81.94	95.0	**96.3**	96.84	**97.64**
300.0	83.33	95.3	**96.6**	96.79	**97.71**
305.0	84.72	95.6	**96.9**	96.79	**97.79**
310.0	86.11	95.9	**97.1**	96.83	**97.86**
315.0	87.50	96.2	**97.4**	96.94	**97.93**
320.0	88.89	96.6	**97.7**	97.11	**98.00**
325.0	90.28	97.0	**98.0**	97.36	**98.29**
330.0	91.67	97.4	**98.3**	97.70	**98.54**
335.0	93.06	97.9	**98.6**	98.13	**98.79**
340.0	94.44	98.5	**98.9**	98.67	**99.04**
345.0	95.83	99.1	**99.1**	99.32	**99.29**
350.0	97.22	99.7	**99.4**	100.10	**99.54**
355.0	98.61	99.8	**99.7**	101.02	**99.79**
360.0	100.00	100.0	**100.0**	102.08	**100.00**

Design By: JG
Check By: EH
Date: 11/14/06

DEPTH-AREA DECAY OBERVED/RECOMMENDED FROM SEVERE STORM EVENTS

Area sq miles	Observed						Recommended			Average
	8/10/1983	6/13/1955	8/10/1981	7/3/1975	10/21/1957	17-Oct	SPS	Hydro-6	Hydro-3	
	DARF									
0.1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**1.000**
1	0.97	0.92	0.96	0.95	0.90	0.95	0.95	0.96	0.93	**0.943**
10	0.88	0.75	0.81	0.87	0.79	0.87	0.85	0.86	0.81	**0.832**
50	0.82	0.69	0.70	0.75	0.76	0.75	0.70	0.80	0.75	**0.710**
100	0.47	0.40	0.52	0.66	0.67	0.67	0.60	0.65	0.78	0.630
200		0.30								0.550
300										0.495
400										0.450
500			0.34	0.41		0.50	0.48			**0.420**
600			0.30							0.390
700				0.30						0.370
800										0.350
900										0.330
1000										0.320
2000										0.200



PB 100 YEARS ®

Design By: JG
Check By: EH
Date: 11/14/06

AREA-WEIGHTING FOR DESIGN RAINFALL DEPTH

				GIS AUTOMATION			
Waterway	AREA ID	Subarea ID	Description	Area A Sq Miles	Depth P inches	Product AxP inches	Average Depth
Patterson Wash	P1	P11	ok	36.45	3.25	118.45	
		P12		132.11	3.75	495.43	
		P13		30.06	4.25	127.76	
	Sum			198.62		741.64	3.73
	P2	P21	ok	98.11	3.25	318.84	
		P22		108.11	3.75	405.41	
		P23		9.40	4.25	39.95	
	Sum			215.62		764.20	3.54
Eagle Wash	E1	E11	OK	73.32	3.25	238.29	
		E12		177.29	3.75	664.83	
		E13		42.89	4.25	182.30	
	Sum			293.50		1085.41	3.70
	E2	E21	ok	95.89	3.25	311.64	
		E22		78.94	3.75	296.03	
		E23		5.84	4.25	24.83	
	Sum			180.67		632.51	3.50
Meadow Wash	M1	M11	ok	28.39	3.25	92.25	
		M12		51.56	3.75	193.33	
		M13		10.00	4.25	42.48	
	Sum			89.94		328.07	3.65
	M2	M21	ok	60.68	3.25	197.22	
		M22		28.59	3.75	107.20	
		M23					
	Sum			89.27		304.42	3.41
	M3	M31	ok	54.20	3.25	176.14	
		M32		14.13	3.75	52.99	
		M33					
	Sum			68.33		229.12	3.35
	M4	M41	ok	21.14	3.25	68.70	
		M42		34.37	3.75	128.88	
		M43					
	Sum			55.51		197.58	3.56
Low M Wash	L1	L11	ok	48.65	3.25	158.11	
		L12		35.88	3.75	134.56	
		L13					
	Sum			84.53		292.68	3.46
	L2	L21	ok	49.59	3.25	161.17	
		L22		73.90	3.75	277.12	
		L23					
	Sum			123.49		438.29	3.55
	L4	L41	ok	192.19	3.75	720.73	
		L42		49.15	4.25	208.90	
		L43					
	Sum			241.35		929.62	3.85
Downst of M Wash							
	Sum						

Appendix II: Beatty Wash Hec-1 Model Output and Hydraulic Capacity Estimation

Design By: JG
Check By: EH
Date: 11/14/06

BEATTY WASH WATERSHED

Watrershed Area	Subarea ID	Area sq mile	Upst Elev ft	Dnst Elev ft	Lenght of Waterway mile	Length to Centroid Mile	Waterway Slope percent	Waterway Slope ft/mile	Curve Number	Roughness Kn	USBR Lag Time hours
Beatty	100	21.99	1750.00	1560.00	6.82	3.41	0.53	27.87	85.00	0.050	1.63
	101	21.66	1800.00	1400.00	5.49	2.75	1.38	72.83	85.00	0.050	1.21
	102	17.96	1400.00	1350.00	10.61	5.30	0.09	4.71	85.00	0.050	2.93
	103	16.22	1600.00	1250.00	7.20	3.60	0.92	48.63	85.00	0.050	1.54
	104	10.86	1250.00	1100.00	7.95	3.98	0.36	18.86	85.00	0.050	1.93
	105	3.19	1350.00	1100.00	4.64	2.32	1.02	53.88	85.00	0.050	1.13
	106	3.93	1250.00	1050.00	3.98	1.99	0.95	50.29	85.00	0.050	1.04
	Total	95.83									

REACH			GIS DATA				DATA Derived									
Reach ID	From	to	Length ft	Upstream Elev ft	Downst Elev ft		Slope ft/ft	Roughness	Depth ft	Velocity fps	K hour	X	N	Low limit 1/(2(1-X))	K/(N*dT) < and <	Hi limit 1/2X
100	100	102	22000.0	1560.0	1400.0		0.0073	0.050	0.50	1.60	3.83	0.10	12.00	0.56	3.83	5.00
101	101	102	12500.0	1400.0	1350.0		0.0040	0.050	0.50	1.18	2.93	0.10	12.00	0.56	2.93	5.00
102	102	103	22000.0	1350.0	1250.0		0.0045	0.050	0.50	1.26	4.84	0.10	20.00	0.56	2.90	5.00
103	103	104	42000.0	1250.0	1100.0		0.0036	0.050	0.50	1.12	10.42	0.10	40.00	0.56	3.13	5.00
104	104	106	15500.0	1100.0	1050.0		0.0032	0.050	0.50	1.06	4.05	0.10	20.00	0.56	2.43	5.00

Subarea ID	Total Area miles	Avg P inches
100	21.99	4.40
101	21.66	4.19
102	17.96	4.15
103	16.22	3.35
104	10.86	2.94
105	3.19	2.77
106	3.93	2.63

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              JAN   1997               *
*            VERSION 4.1                *
*                                       *
*   RUN DATE  21OCT05  TIME  12:22:27   *
*                                       *
*****************************************

*****************************************
*                                       *
*     U.S. ARMY CORPS OF ENGINEERS      *
*    HYDROLOGIC ENGINEERING CENTER      *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*           (916) 756-1104              *
*                                       *
*****************************************

X     X  XXXXXXX   XXXXX           X
X     X  X        X     X         XX
X     X  X        X                X
XXXXXXX  XXXX     X        XXXXX   X
X     X  X        X                X
X     X  X        X     X          X
X     X  XXXXXXX   XXXXX          XXX


THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81.  THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1                                HEC-1 INPUT                                        PAGE  1

        LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

                    *DIAGRAM
          1         ID
          2         ID
          3         ID      *****************************************************************
          4         ID      *  ALL AREAS of **** sq miles                                    *
          5         ID      *  Beatty Wash at SH 95 Bridge -- double 5 x8 -ft CBC             *
          6         ID      *****************************************************************
          7         ID
          8         ID      24-hr 100-year event-- Convective Storm
          9         ID      prepared by PB-Water Division for Mina Railroad Route Study
         10         ID
         11         ID      PREC    0.815 0.720 0.700 0.670 0.640 0.630
         12         ID      AREA    22.00 43.50 61.60 77.80 92.00 95.80
 *** FREE ***
         13         IT       15       0       0     250
         14         IO        5       0       0
         15         IN       15       0       0
         16         JR     PREC   0.815   0.720   0.700   0.670   0.640   0.630

         17         KK     B100
         18         KM     Subarea 100
         19         BA     21.99
         20         PB      4.40
         21         PC     .000    .044    .087    .128    .168    .206    .243    .279    .313    .346
         22         PC     .378    .408    .437    .465    .492    .518    .543    .567    .589    .611
         23         PC     .632    .652    .671    .689    .706    .722    .738    .753    .767    .780
         24         PC     .793    .805    .816    .827    .837    .846    .855    .864    .872    .879
         25         PC     .886    .892    .898    .904    .909    .914    .919    .923    .927    .931
         26         PC     .934    .937    .940    .943    .945    .947    .949    .951    .952    .954
         27         PC     .956    .957    .958    .959    .960    .961    .962    .963    .964    .965
         28         PC     .966    .967    .968    .969    .969    .970    .971    .972    .974    .975
         29         PC     .976    .977    .978    .980    .982    .983    .985    .987    .989    .991
         30         PC     .993    .995    .996    .997    .998    1.00
         31         LS        0      85
         32         UD     1.63

         33         KKR100-101
         34         KM     Route from 100 to 101
         35         RM     12.0     3.83    0.10

         36         KK     B101
         37         KM     Subarea 101
         38         BA     21.66
         39         PB      4.19
         40         LS        0      85
         41         UD     1.21

         42         KKR100-101 + B101
         43         KM     Combine R100-101 and B101
         44         HC        2
1                                HEC-1 INPUT                                        PAGE  2

        LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


         45         KKR101-102
         46         KM     Route from 101 to 102
         47         RM     12.0     2.93    0.10

         48         KK     B102
         49         KM     Subarea 102
         50         BA     17.96
         51         PB      4.15
         52         LS        0      85
         53         UD     2.93

         54         KKR101-102 + B102
         55         KM     Combine R101-102 and B102
         56         HC        2

         57         KKR102-103
         58         KM     Route from 102 to 103
         59         RM     20.0     2.90    0.10
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60          KK    B103
61          KM    Subarea 103
62          BA    16.22
63          PB     3.35
64          LS       0      85
65          UD     1.54

66          KKR102-103 + B103
67          KM    Combine R102-103 and B103
68          HC       2

69          KKR103-104
70          KM    Route through B104
71          RM     40.0     3.13      0.1

72          KK    B104
73          KM    Subarea B104
74          BA    10.86
75          PB     2.94
76          LS       0      85
77          UD     1.93

78          KK    B105
79          KM    Subarea B105
80          BA     3.19
81          PB     2.77
82          LS       0      85
83          UD     1.13

84          KKR104-105 + B104+B105
85          KM    Combine R104-105, B104, and B105
86          HC       3
1                                           HEC-1 INPUT                                      PAGE  3

  LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

87          KKR105-106
88          KM    Route through B106
89          RM     20.0     2.43      0.1

90          KK    B106
91          KM    Subarea B106
92          BA     3.93
93          PB     2.63
94          LS       0      85
95          UD     1.04

96          KKR105-106+B106
97          KM    Combine R105-106+B106
98          HC       2
99          ZZ
1
              SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE     (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

 NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  17         B100
                V
                V
  33      R100-101
                .
                .
  36            .          B101
                .             .
                .             .
  42      R100-101............
                V
                V
  45      R101-102
                .
                .
  48            .          B102
                .             .
                .             .
  54      R101-102............
                V
                V
  57      R102-103
                .
                .
  60            .          B103
                .             .
                .             .
  66      R102-103............
                V
                V
  69      R103-104
                .
                .
  72            .          B104
                .             .
                .             .
  78            .             .          B105
                .             .             .
                .             .             .
  84      R104-105.......................
                V
                V
  87      R105-106
                .
                .
  90            .          B106
                .             .
                .             .
  96      R105-106............

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************                          *****************************************
 *                                       *                          *                                       *
```

```
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*         JAN   1997                  *
*       VERSION 4.1                   *
*                                     *
*  RUN DATE   21OCT06  TIME  12:22:27 *
*                                     *
***************************************

*   U.S. ARMY CORPS OF ENGINEERS       *
*   HYDROLOGIC ENGINEERING CENTER      *
*        609 SECOND STREET             *
*     DAVIS, CALIFORNIA 95616          *
*         (916) 756-1104               *
*                                      *
****************************************

*****************************************************************
*  ALL AREAS of **** sq miles                                   *
*  Beatty Wash at SH 95 Bridge -- double 5 x8 -ft CBC              *
*****************************************************************

24-hr 100-year event-- Convective Storm
prepared by PB-Water Division for Mina Railroad Route Study

PREC    0.815 0.720 0.700 0.670 0.640 0.630
AREA    22.00 43.50 61.60 77.80 92.00 95.80

14 IO         OUTPUT CONTROL VARIABLES
                    IPRNT          5  PRINT CONTROL
                    IPLOT          0  PLOT CONTROL
                    QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                     NMIN         15  MINUTES IN COMPUTATION INTERVAL
                    IDATE      1   0  STARTING DATE
                    ITIME       0000  STARTING TIME
                       NQ        250  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE      3   0  ENDING DATE
                   NDTIME       1415  ENDING TIME
                    ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                   TOTAL TIME BASE   62.25 HOURS

        ENGLISH UNITS
              DRAINAGE AREA          SQUARE MILES
              PRECIPITATION DEPTH    INCHES
              LENGTH, ELEVATION      FEET
              FLOW                   CUBIC FEET PER SECOND
              STORAGE VOLUME         ACRE-FEET
              SURFACE AREA           ACRES
              TEMPERATURE            DEGREES FAHRENHEIT

   JP         MULTI-PLAN OPTION
                    NPLAN          1  NUMBER OF PLANS

   JR         MULTI-RATIO OPTION
                 RATIOS OF PRECIPITATION
                .81      .72      .70      .67      .64      .63
1

    PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                 FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                TIME TO PEAK IN HOURS
```

OPERATION	STATION	AREA	PLAN		RATIO 1 .81	RATIO 2 .72	RATIO 3 .70	RATIO 4 .67	RATIO 5 .64	RATIO 6 .63
+ HYDROGRAPH AT	B100	21.99	1	FLOW	3408.	2802.	2679.	2494.	2311.	2251.
				TIME	5.50	5.75	5.75	5.75	5.75	5.75
+ ROUTED TO	R100-101	21.99	1	FLOW	3233.	2663.	2545.	2370.	2198.	2141.
				TIME	9.50	9.75	9.75	9.75	10.00	10.00
+ HYDROGRAPH AT	B101	21.66	1	FLOW	3232.	2647.	2526.	2350.	2175.	2118.
				TIME	5.00	5.00	5.00	5.25	5.25	5.25
+ 2 COMBINED AT	R100-101	43.65	1	FLOW	5175.	4264.	4076.	3797.	3522.	3430.
				TIME	8.50	8.75	8.75	8.75	8.75	8.75
+ ROUTED TO	R101-102	43.65	1	FLOW	5062.	4172.	3989.	3717.	3448.	3359.
				TIME	11.50	11.75	11.75	11.75	11.75	11.75
+ HYDROGRAPH AT	B102	17.96	1	FLOW	2242.	1841.	1758.	1636.	1516.	1476.
				TIME	7.50	7.50	7.50	7.75	7.75	7.75
+ 2 COMBINED AT	R101-102	61.61	1	FLOW	6628.	5466.	5227.	4870.	4517.	4401.
				TIME	10.75	11.00	11.00	11.00	11.00	11.00
+ ROUTED TO	R102-103	61.61	1	FLOW	6571.	5418.	5180.	4827.	4479.	4364.
				TIME	13.75	13.75	13.75	14.00	14.00	14.00
+ HYDROGRAPH AT	B103	16.22	1	FLOW	1633.	1319.	1256.	1161.	1068.	1038.
				TIME	5.75	6.00	6.00	6.00	6.00	6.25
+ 2 COMBINED AT	R102-103	77.83	1	FLOW	6990.	5761.	5507.	5130.	4758.	4635.
				TIME	13.25	13.50	13.50	13.50	13.50	13.50
+ ROUTED TO	R103-104	77.83	1	FLOW	6962.	5739.	5486.	5110.	4739.	4617.
				TIME	16.50	16.50	16.50	16.50	16.75	16.75

HYDROGRAPH AT	B104	10.86	1	FLOW TIME	843. 6.50	675. 6.75	641. 6.75	590. 6.75	541. 7.00	525. 7.00
+ HYDROGRAPH AT	B105	3.19	1	FLOW TIME	239. 5.50	190. 5.75	180. 5.75	166. 5.75	151. 5.75	147. 5.75
+ 3 COMBINED AT	R104-105	91.88	1	FLOW TIME	7104. 16.25	5851. 16.25	5592. 16.25	5209. 16.50	4830. 16.50	4705. 16.50
+ ROUTED TO	R105-106	91.88	1	FLOW TIME	7079. 18.50	5831. 18.75	5573. 18.75	5191. 18.75	4813. 18.75	4688. 18.75
+ HYDROGRAPH AT	B106	3.93	1	FLOW TIME	269. 5.25	213. 5.50	202. 5.75	185. 5.75	169. 5.75	164. 5.75
+ 2 COMBINED AT	R105-106	95.81	1	FLOW TIME	7096. 18.50	5844. 18.75	5586. 18.75	5202. 18.75	4823. 18.75	4698. 18.75

*** NORMAL END OF HEC-1 ***

Design By: JG
Check By: EH
Date: 11/14/06

RESULTS FOR BEATTY WASH

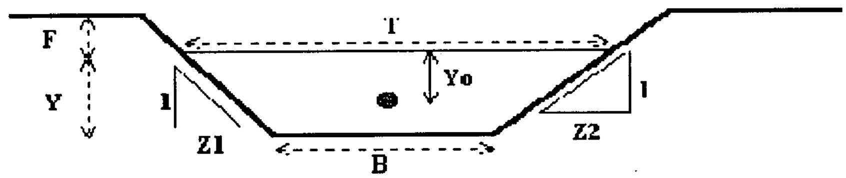
Using 24-hr Convective Storm **P24**
SCS CN for desert area **85**
No Detention

Location	Drainage Area sq miles	DARF	100-yr HEC-1 Peak cfs	CN=85 FEMA Peak cfs	AMC2 Freq-Q Peak cfs	10-yr HEC-1 Peak cfs	CN=85 FEMA Peak cfs	AMC2 Freq-Q Peak cfs	2-yr HEC-1 Peak cfs	Cn=70 FEMA Peak cfs	AMC1 Freq-Q Peak cfs
	21.99	0.815	3408.0								
	43.56	0.720	4172.0								
	61.61	0.700	5227.0								
	77.83	0.670	5130.0								
	91.88	0.640	4813.0								
2-8'x10'RCB	95.81	0.630	4698.0								

Footnote: The existing double 8' x 10' BCB can pass 4774 cfs at y=8 feet with n=0.014, and S=0.01 ft/ft.

Normal Flow Analysis - Trapezoidal Channel

Project: **Mina Route**
Channel ID: **Existing double 8x10 RCB on US 95 (capacity estimation) for Beatty **



Design Information (Input)			
Channel Invert Slope	So =	0.0100	ft/ft
Channel Manning's N	N =	0.014	
Bottom Width	B =	20.0	ft
Left Side Slope	Z1 =	0.0	ft/ft
Right Side Slope	Z2 =	0.0	ft/ft
Freeboard Height	F =	0.5	ft
Design Water Depth	Y =	**8.00**	ft

Normal Flow Condtion (Calculated)			
Discharge	**Q =**	**4,773.7**	cfs
Froude Number	**Fr =**	**1.86**	
Flow Velocity	**V =**	**29.8**	fps
Flow Area	A =	160.0	sq ft
Top Width	T =	20.0	ft
Wetted Perimeter	P =	36.0	ft
Hydraulic Radius	R =	4.4	ft
Hydraulic Depth	D =	8.0	ft
Specific Energy	Es =	21.8	ft
Centroid of Flow Area	Yo =	4.0	ft
Specific Force	Fs =	316.2	kip

Appendix III: Amargosa Wash Hec-1 Model Output and Hydraulic Capacity Estimation

Design By: JG
Check By: EH
Date: 11/14/06

AMARGOSA WASH WATERSHED PARAMETERS

Watrershed Area	Subarea ID	Area sq mile	Upst Elev ft	Dnst Elev ft	Lenght of Waterway mile	Length to Centroid Mile	Waterway Slope percent	Waterway Slope ft/mile	Curve Number	Roughness Kn	USBR Lag Time hours	Precip 100yr24hr inch
Beatty	100	112.97	1900.00	1350.00	21.78	10.89	0.48	25.25	85.00	0.050	3.57	3.43
	101	83.54	1800.00	1350.00	16.86	8.43	0.51	26.70	85.00	0.050	2.99	3.89
	102	39.58	1700.00	1150.00	18.56	6.06	0.56	29.63	85.00	0.050	2.72	3.10
	103	35.14	1750.00	1150.00	18.18	9.09	0.63	33.00	85.00	0.050	3.03	3.84
	105	29.92	1500.00	1150.00	12.69	6.34	0.52	27.58	85.00	0.050	2.46	2.89
	104	21.08	1400.00	1100.00	7.95	3.98	0.71	37.71	85.00	0.050	1.72	2.89
		322.23										

REACH			GIS DATA				DATA	Derived								
Reach ID	From	to	Length ft	Upstream Elev ft	Downst Elev ft		Slope ft/ft	Roughness	Depth ft	Velocity fps	K hour	X	N	Low limit 1/(2(1-X)	K/(N*dT) < and <	Hi limit 1/2X
100	101	103	59000.0	1350.0	1150.0		0.0034	0.050	0.50	1.09	15.03	0.10	50.00	0.56	3.61	5.00
101	103	104	16000.0	1150.0	1100.0		0.0031	0.050	1.00	1.67	2.67	0.10	20.00	0.56	1.60	5.00

Subarea ID	Total Area miles	Avg P inches
100	112.97	3.43
101	83.54	3.89
102	39.58	3.10
103	35.14	3.84
105	29.92	2.89
104	21.08	2.89

```
1*****************************************                  ******************************************
 *                                       *                  *                                        *
 *   FLOOD HYDROGRAPH PACKAGE   (HEC-1)  *                  *   U.S. ARMY CORPS OF ENGINEERS         *
 *              JAN  1997                *                  *   HYDROLOGIC ENGINEERING CENTER        *
 *            VERSION 4.1                *                  *          609 SECOND STREET             *
 *                                       *                  *        DAVIS, CALIFORNIA 95616         *
 * RUN DATE   10DEC06  TIME  09:20:17    *                  *           (916) 756-1104               *
 *                                       *                  *                                        *
 *****************************************                  ******************************************


                    X       X  XXXXXXX   XXXXX           X
                    X       X  X        X     X         XX
                    X       X  X        X                X
                    XXXXXXX    XXXX     X        XXXXX   X
                    X       X  X        X                X
                    X       X  X        X     X          X
                    X       X  XXXXXXX   XXXXX          XXX


THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL    LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1                                          HEC-1 INPUT                                        PAGE  1

         LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

                   *DIAGRAM
            1      ID
            2      ID
            3      ID    *****************************************************************
            4      ID    *  ALL AREAS of **** sq miles                                    *
            5      ID    *  Amargosa Wash at SH 95 Bridge -- 140-ft by 5ft Bridge         *
            6      ID    *****************************************************************
            7      ID
            8      ID    24-hr 100-year event-- Convective Storm
            9      ID    prepared by PB-Water Division for Mina Railroad Route Study
           10      ID
           11      ID    PREC     0.730 0.670 0.610 0.550 0.515 0.495 0.485
           12      ID    AREA     42.00 83.50 113.0 196.0 271.0 300.0 322.0
*** FREE ***
           13      IT       15       0       0     250
           14      IO        5       0       0
           15      IN       15       0       0
           16      JR     PREC   0.730   0.670   0.610   0.550   0.515   0.495   0.485

           17      KK     B100
           18      KM     Subarea 100
           19      BA   112.97
           20      PB     3.43
           21      PC     .000    .044    .087    .128    .168    .206    .243    .279    .313    .346
           22      PC     .378    .408    .437    .465    .492    .518    .543    .567    .589    .611
           23      PC     .632    .652    .671    .689    .706    .722    .738    .753    .767    .780
           24      PC     .793    .805    .816    .827    .837    .846    .855    .864    .872    .879
           25      PC     .886    .892    .898    .904    .909    .914    .919    .923    .927    .931
           26      PC     .934    .937    .940    .943    .945    .947    .949    .951    .952    .954
           27      PC     .956    .957    .958    .959    .960    .961    .962    .963    .964    .965
           28      PC     .966    .967    .968    .969    .969    .970    .971    .972    .974    .975
           29      PC     .976    .977    .978    .980    .982    .983    .985    .987    .989    .991
           30      PC     .993    .995    .996    .997    .998    1.00
           31      LS        0      85
           32      UD     3.57

           33      KK     B101
           34      KM     Subarea 101
           35      BA    83.54
           36      PB     3.89
           37      LS        0      85
           38      UD     2.99

           39      KK     B100+ B101
           40      KM     Combine B100 and B101
           41      HC        2

           42      KKR101-103
           43      KM     Route from 101 to 103
           44      RM     50.0    3.61    0.10
1                                          HEC-1 INPUT                                        PAGE  2

         LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


           45      KK     B102
           46      KM     Subarea 102
           47      BA    39.58
           48      PB     3.10
           49      LS        0      85
           50      UD     2.36

           51      KK     B103
           52      KM     Subarea 103
           53      BA    35.14
           54      PB     3.84
           55      LS        0      85
           56      UD     3.03

           57      KKR101-103+B102+B103
           58      KM     Combine R101-103, B102 and B103
           59      HC        3

           60      KK     B105
```

```
            61          KM    Subarea B105
            62          BA    29.92
            63          PB     2.89
            64          LS       0       85
            65          UD     2.46

            66          KK     R103+ B105
            67          KM    Combine R103 and B105
            68          HC        2

            69          KKR105-104
            70          KM    Route through B104
            71          RM     20.0     1.60     0.1

            72          KK     B104
            73          KM    Subarea B104
            74          BA    21.08
            75          PB     2.89
            76          LS       0       85
            77          UD     1.72

            78          KKR105+B104
            79          KM    Combine R105+B104
            80          HC        2
            81          ZZ
1
                   SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
 LINE        (V) ROUTING            (--->) DIVERSION OR PUMP FLOW

  NO.        (.) CONNECTOR          (<---) RETURN OF DIVERTED OR PUMPED FLOW

  17          B100
                .
                .
  33            .       B101
                .         .
                .         .
  39          B100.........
                V
                V
  42       R101-103
                .
                .
  45            .       B102
                .         .
                .         .
  51            .         .       B103
                .         .         .
                .         .         .
  57       R101-103.....................
                .
                .
  60            .       B105
                .         .
                .         .
  66          R103.........
                V
                V
  69       R105-104
                .
                .
  72            .       B104
                .         .
                .         .
  78       R105+B10.........

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************                  *****************************************
 *                                       *                  *                                       *
 *   FLOOD HYDROGRAPH PACKAGE   (HEC-1)  *                  *   U.S. ARMY CORPS OF ENGINEERS        *
 *             JAN   1997                *                  *   HYDROLOGIC ENGINEERING CENTER       *
 *           VERSION 4.1                 *                  *         609 SECOND STREET             *
 *                                       *                  *      DAVIS, CALIFORNIA 95616          *
 *   RUN DATE    10DEC06   TIME  09:20:17 *                 *         (916) 756-1104                *
 *                                       *                  *                                       *
 *****************************************                  *****************************************



                         *****************************************************************
                         *  ALL AREAS of **** sq miles                                   *
                         *  Amargosa Wash at SH 95 Bridge -- 140-ft by 5ft Bridge        *
                         *****************************************************************

                         24-hr 100-year event-- Convective Storm
                         prepared by PB-Water Division for Mina Railroad Route Study

                         PREC     0.730 0.670 0.610 0.550 0.515 0.495 0.485
                         AREA     42.00 83.50 113.0 196.0 271.0 300.0 322.0

  14 IO         OUTPUT CONTROL VARIABLES
                      IPRNT            5   PRINT CONTROL
                      IPLOT            0   PLOT CONTROL
                      QSCAL           0.   HYDROGRAPH PLOT SCALE

     IT         HYDROGRAPH TIME DATA
                       NMIN           15   MINUTES IN COMPUTATION INTERVAL
                      IDATE        1   0   STARTING DATE
                      ITIME         0000   STARTING TIME
                         NQ          250   NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE        3   0   ENDING DATE
                     NDTIME         1415   ENDING TIME
                      ICENT           19   CENTURY MARK

               COMPUTATION INTERVAL     .25 HOURS
                    TOTAL TIME BASE   62.25 HOURS
```

```
ENGLISH UNITS
     DRAINAGE AREA          SQUARE MILES
     PRECIPITATION DEPTH    INCHES
     LENGTH, ELEVATION      FEET
     FLOW                   CUBIC FEET PER SECOND
     STORAGE VOLUME         ACRE-FEET
     SURFACE AREA           ACRES
     TEMPERATURE            DEGREES FAHRENHEIT

JP          MULTI-PLAN OPTION
                 NPLAN            1  NUMBER OF PLANS

JR          MULTI-RATIO OPTION
                 RATIOS OF PRECIPITATION
                  .73      .67      .61      .55      .51      .50      .49
1
```

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES
TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN		RATIOS APPLIED TO PRECIPITATION RATIO 1 .73	RATIO 2 .67	RATIO 3 .61	RATIO 4 .55	RATIO 5 .51	RATIO 6 .50	RATIO 7 .49
HYDROGRAPH AT +	B100	112.97	1	FLOW	8136.	7010.	5920.	4879.	4296.	3973.	3813.
				TIME	8.75	8.75	9.00	9.00	9.25	9.25	9.25
HYDROGRAPH AT +	B101	83.54	1	FLOW	7839.	6791.	5780.	4803.	4258.	3952.	3801.
				TIME	7.75	7.75	8.00	8.25	8.25	8.25	8.25
2 COMBINED AT +	B100	196.51	1	FLOW	15861.	13700.	11615.	9608.	8489.	7864.	7555.
				TIME	8.25	8.25	8.50	8.50	8.75	8.75	8.75
ROUTED TO +	R101-103	196.51	1	FLOW	15751.	13612.	11534.	9549.	8429.	7812.	7507.
				TIME	11.75	12.00	12.00	12.25	12.50	12.50	12.50
HYDROGRAPH AT +	B102	39.58	1	FLOW	2669.	2284.	1916.	1564.	1369.	1261.	1208.
				TIME	7.25	7.25	7.50	7.75	7.75	8.00	8.00
HYDROGRAPH AT +	B103	35.14	1	FLOW	3216.	2784.	2368.	1967.	1742.	1615.	1554.
				TIME	7.75	8.00	8.00	8.25	8.25	8.50	8.50
3 COMBINED AT +	R101-103	271.23	1	FLOW	19645.	16959.	14376.	11889.	10497.	9718.	9336.
				TIME	11.25	11.50	11.50	11.75	11.75	11.75	12.00
HYDROGRAPH AT +	B105	29.92	1	FLOW	1761.	1501.	1252.	1017.	886.	814.	778.
				TIME	7.50	7.50	7.75	8.00	8.00	8.25	8.25
2 COMBINED AT +	R103	301.15	1	FLOW	20844.	17998.	15234.	12595.	11107.	10287.	9881.
				TIME	11.00	11.25	11.25	11.50	11.75	11.75	11.75
ROUTED TO +	R105-104	301.15	1	FLOW	20785.	17936.	15192.	12551.	11078.	10255.	9848.
				TIME	12.75	12.75	13.00	13.25	13.25	13.25	13.25
HYDROGRAPH AT +	B104	21.08	1	FLOW	1327.	1130.	942.	764.	666.	611.	585.
				TIME	6.50	6.50	6.75	7.00	7.00	7.00	7.25
2 COMBINED AT +	R105+B10	322.23	1	FLOW	21283.	18374.	15548.	12850.	11332.	10492.	10077.
				TIME	12.75	12.75	13.00	13.00	13.25	13.25	13.25

*** NORMAL END OF HEC-1 ***

Design By: JG
Check By: EH
Date: 11/14/06

RESULTS FOR AMARGOSA WASH at US95

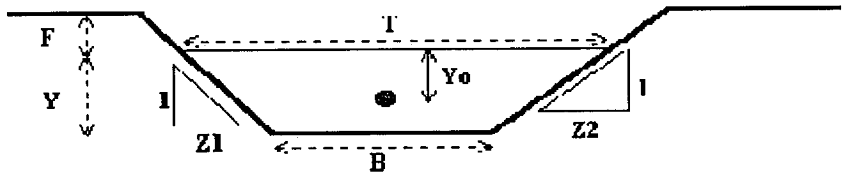
Using 24-hr Convective Storm **P24**
SCS CN for desert area **85**
No Detention

Location	Drainage Area	DARF	100-yr	CN=85	AMC2	10-yr	CN=85	AMC2	2-yr	Cn=70	AMC1
			HEC-1 Peak cfs	FEMA Peak cfs	Freq-Q Peak cfs	HEC-1 Peak cfs	FEMA Peak cfs	Freq-Q Peak cfs	HEC-1 Peak cfs	FEMA Peak cfs	Freq-Q Peak cfs
	sq miles										
	42.00	0.730	2861.0								
	83.30	0.670	6774.0								
	113.00	0.610	5939.0								
	196.00	0.550	9611.0								
	271.00	0.515	11851.0								
140' span bridge	322.0	0.48	10077.0								

Footnote: The bridge opening under US 95 has a bottom width of 140 feet and a side slope of 2H:1V.
Let S=0.01 ft/ft, n=0.025, the flow depth is approximately 4.5 feet for Q=10382 cfs.
During the field trip, a water mark of 4.5 feet was observed on the bridge pier.

Normal Flow Analysis - Trapezoidal Channel

Project: Mina Route
Channel ID: Existing 140' Span Bridge on US 95 (capacity estimation) for Amargo



Design Information (Input)			
Channel Invert Slope	So =	0.0100	ft/ft
Channel Manning's N	N =	0.025	
Bottom Width	B =	140.0	ft
Left Side Slope	Z1 =	2.0	ft/ft
Right Side Slope	Z2 =	2.0	ft/ft
Freeboard Height	F =	0.5	ft
Design Water Depth	Y =	**4.50**	ft
Normal Flow Condtion (Calculated)			
Discharge	**Q =**	**10,381.8**	cfs
Froude Number	**Fr =**	**1.32**	
Flow Velocity	**V =**	**15.5**	fps
Flow Area	A =	670.5	sq ft
Top Width	T =	158.0	ft
Wetted Perimeter	P =	160.1	ft
Hydraulic Radius	R =	4.2	ft
Hydraulic Depth	D =	4.2	ft
Specific Energy	Es =	8.2	ft
Centroid of Flow Area	Yo =	2.2	ft
Specific Force	Fs =	404.1	kip

Appendix IV: Regression Analyses and USGS Stream Gage Data Comparison

```
1****************************************                          ****************************************
*                                       *                          *                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                          *   U.S. ARMY CORPS OF ENGINEERS       *
*              JAN   1997               *                          *   HYDROLOGIC ENGINEERING CENTER      *
*           VERSION 4.1                 *                          *        609 SECOND STREET             *
*                                       *                          *     DAVIS, CALIFORNIA 95616          *
* RUN DATE   10DEC06   TIME  10:06:17   *                          *        (916) 756-1104                *
*                                       *                          *                                      *
*****************************************                          ****************************************


                 X     X  XXXXXXX   XXXXX          X
                 X     X  X        X     X        XX
                 X     X  X        X               X
                 XXXXXXX  XXXX     X       XXXXX   X
                 X     X  X        X               X
                 X     X  X        X     X         X
                 X     X  XXXXXXX   XXXXX         XXX


THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1                                        HEC-1 INPUT                                        PAGE  1

     LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

                *DIAGRAM
        1       ID
        2       ID
        3       ID     ****************************************************************
        4       ID     *  ALL AREAS of **** sq miles                                   *
        5       ID     *  Beatty Wash and Amargosa Wash                                *
        6       ID     ****************************************************************
        7       ID
        8       ID     24-hr 100-year event-- Convective Storm
        9       ID     prepared by PB-Water Division for Mina Railroad Route Study
       10       ID
       11       ID     PREC    0.730 0.670 0.610 0.550 0.515 0.495 0.450
       12       ID     AREA    42.00 83.50 113.0 196.0 271.0 296.0 400.0
*** FREE ***
       13       IT      15       0       0     250
       14       IO       5       0       0
       15       IN      15       0       0
                *  JR PREC 0.730 0.670 0.610 0.550 0.515 0.495
       16       JR    PREC    0.45

       17       KK    B100
       18       KM    Subarea 100
       19       BA  112.97
       20       PB    3.43
       21       PC    .000    .044    .087    .128    .168    .206    .243    .279    .313    .346
       22       PC    .378    .408    .437    .465    .492    .518    .543    .567    .589    .611
       23       PC    .632    .652    .671    .689    .706    .722    .738    .753    .767    .780
       24       PC    .793    .805    .816    .827    .837    .846    .855    .864    .872    .879
       25       PC    .886    .892    .898    .904    .909    .914    .919    .923    .927    .931
       26       PC    .934    .937    .940    .943    .945    .947    .949    .951    .952    .954
       27       PC    .956    .957    .958    .959    .960    .961    .962    .963    .964    .965
       28       PC    .966    .967    .968    .969    .969    .970    .971    .972    .974    .975
       29       PC    .976    .977    .978    .980    .982    .983    .985    .987    .989    .991
       30       PC    .993    .995    .996    .997    .998    1.00
       31       LS       0      85
       32       UD    3.57

       33       KK    B101
       34       KM    Subarea 101
       35       BA   83.54
       36       PB    3.89
       37       LS       0      85
       38       UD    2.99

       39       KK    B100+ B101
       40       KM    Combine B100 and B101
       41       HC       2

       42       KKR101-103
       43       KM    Route from 101 to 103
       44       RM    50.0    3.61    0.10
1                                        HEC-1 INPUT                                        PAGE  2

     LINE       ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


       45       KK    B102
       46       KM    Subarea 102
       47       BA   39.58
       48       PB    3.10
       49       LS       0      85
       50       UD    2.36

       51       KK    B103
       52       KM    Subarea 103
       53       BA   35.14
       54       PB    3.84
       55       LS       0      85
       56       UD    3.03

       57       KKR101-103+B102+B103
       58       KM    Combine R101-103, B102 and B103
       59       HC       3
```

```
 60          KK      105
 61          KM    Subarea B105
 62          BA    29.92
 63          PB     2.89
 64          LS        0        85
 65          UD     2.46

 66          KK     R103+ B105
 67          KM    Combine R103 and B105
 68          HC        2

 69          KKR105-104
 70          KM    Route through B104
 71          RM     20.0     1.60      0.1

 72          KK     B104
 73          KM    Subarea B104
 74          BA    21.08
 75          PB     2.89
 76          LS        0        85
 77          UD     1.72

 78          KKR105+B104
 79          KM    Combine R105+B104
 80          HC        2
             *
             *  Beatty Wash

 81          KK     B100
 82          KM    Subarea 100
 83          BA    21.99
 84          PB     4.40
 85          LS        0        85
 86          UD     1.63
1                                     HEC-1 INPUT                                        PAGE  3

 LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 87          KKR100-101
 88          KM    Route from 100 to 101
 89          RM     12.0     3.83     0.10

 90          KK     B101
 91          KM    Subarea 101
 92          BA    21.66
 93          PB     4.19
 94          LS        0        85
 95          UD     1.21

 96          KKR100-101 + B101
 97          KM    Combine R100-101 and B101
 98          HC        2

 99          KKR101-102
100          KM    Route from 101 to 102
101          RM     12.0     2.93     0.10

102          KK     B102
103          KM    Subarea 102
104          BA    17.96
105          PB     4.15
106          LS        0        85
107          UD     2.93

108          KKR101-102 + B102
109          KM    Combine R101-102 and B102
110          HC        2

111          KKR102-103
112          KM    Route from 102 to 103
113          RM     20.0     2.90     0.10

114          KK     B103
115          KM    Subarea 103
116          BA    16.22
117          PB     3.35
118          LS        0        85
119          UD     1.54

120          KKR102-103 + B103
121          KM    Combine R102-103 and B103
122          HC        2

123          KKR103-104
124          KM    Route through B104
125          RM     40.0     3.13      0.1
1                                     HEC-1 INPUT                                        PAGE  4

 LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

126          KK     B104
127          KM    Subarea B104
128          BA    10.86
129          PB     2.94
130          LS        0        85
131          UD     1.93

132          KK     B105
133          KM    Subarea B105
134          BA     3.19
135          PB     2.77
136          LS        0        85
137          UD     1.13

138          KKR104-105 + B104+B105
139          KM    Combine R104-105, B104, and B105
140          HC        3

141          KKR105-106
142          KM    Route through B106
```

```
       143          RM    20.0    2.43     0.1

       144          KK    B106
       145          KM   Subarea B106
       146          BA    3.93
       147          PB    2.63
       148          LS       0       85
       149          UD    1.04

       150          KKR105-106+B106
       151          KM   Combine R105-106+B106
       152          HC       2

       153          KKComtotal
       154          KM   Total Sum at gage
       155          HC       2
       156          ZZ
1
              SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

 NO.       (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  17        B100
              .
  33          .         B101
              .           .
  39        B100...........
              V
              V
  42     R101-103
              .
  45          .         B102
              .           .
  51          .           .         B103
              .           .           .
  57     R101-103.....................
              .
  60          .          105
              .           .
  66        R103...........
              V
              V
  69     R105-104
              .
  72          .         B104
              .           .
  78     R105+B10...........
              .
  81          .         B100
              .           V
              .           V
  87          .      R100-101
              .           .
  90          .           .         B101
              .           .           .
  96          .      R100-101...........
              .           V
              .           V
  99          .      R101-102
              .           .
 102          .           .         B102
              .           .           .
 108          .      R101-102...........
              .           V
              .           V
 111          .      R102-103
              .           .
 114          .           .         B103
              .           .           .
 120          .      R102-103...........
              .           V
              .           V
 123          .      R103-104
              .           .
 126          .           .         B104
              .           .           .
 132          .           .           .         B105
              .           .           .           .
 138          .      R104-105.......................
              .           V
              .           V
 141          .      R105-106
              .           .
 144          .           .         B106
              .           .           .
 150          .      R105-106...........
              .           .
 153     Comtotal...........
```

```
(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
*****************************************
*                                       *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)    *
*          JAN   1997                   *
*        VERSION 4.1                    *
*                                       *
*  RUN DATE   10DEC06  TIME  10:06:17   *
*                                       *
*****************************************

*****************************************
*                                       *
*  U.S. ARMY CORPS OF ENGINEERS         *
*  HYDROLOGIC ENGINEERING CENTER        *
*       609 SECOND STREET               *
*     DAVIS, CALIFORNIA 95616           *
*        (916) 756-1104                 *
*                                       *
*****************************************

*****************************************************************
* ALL AREAS of **** sq miles                                    *
* Beatty Wash and Amargosa Wash                                 *
*****************************************************************

24-hr 100-year event-- Convective Storm
prepared by PB-Water Division for Mina Railroad Route Study

PREC    0.730 0.670 0.610 0.550 0.515 0.495 0.450
AREA    42.00 83.50 113.0 196.0 271.0 296.0 400.0

14 IO          OUTPUT CONTROL VARIABLES
                    IPRNT          5  PRINT CONTROL
                    IPLOT          0  PLOT CONTROL
                    QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT          HYDROGRAPH TIME DATA
                     NMIN         15  MINUTES IN COMPUTATION INTERVAL
                    IDATE      1   0  STARTING DATE
                    ITIME       0000  STARTING TIME
                       NQ        250  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE      3   0  ENDING DATE
                   NDTIME       1415  ENDING TIME
                    ICENT         19  CENTURY MARK

           COMPUTATION INTERVAL    .25 HOURS
                TOTAL TIME BASE  62.25 HOURS

        ENGLISH UNITS
             DRAINAGE AREA          SQUARE MILES
             PRECIPITATION DEPTH    INCHES
             LENGTH, ELEVATION      FEET
             FLOW                   CUBIC FEET PER SECOND
             STORAGE VOLUME         ACRE-FEET
             SURFACE AREA           ACRES
             TEMPERATURE            DEGREES FAHRENHEIT

   JP          MULTI-PLAN OPTION
                    NPLAN            1  NUMBER OF PLANS

   JR          MULTI-RATIO OPTION
                 RATIOS OF PRECIPITATION
1

        PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                      FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                     TIME TO PEAK IN HOURS

                                                          RATIOS APPLIED TO PRECIPITATION
OPERATION         STATION      AREA    PLAN               RATIO 1
                                                             .45

HYDROGRAPH AT
+                   B100     112.97      1    FLOW        3270.
                                              TIME         9.50

HYDROGRAPH AT
+                   B101      83.54      1    FLOW        3287.
                                              TIME         8.50

 2 COMBINED AT
+                   B100     196.51      1    FLOW        6506.
                                              TIME         9.00

ROUTED TO
+               R101-103     196.51      1    FLOW        6461.
                                              TIME        12.50

HYDROGRAPH AT
+                   B102      39.58      1    FLOW        1028.
                                              TIME         8.00

HYDROGRAPH AT
+                   B103      35.14      1    FLOW        1343.
                                              TIME         8.50

 3 COMBINED AT
+               R101-103     271.23      1    FLOW        8037.
                                              TIME        12.00

HYDROGRAPH AT
+                    105      29.92      1    FLOW         658.
                                              TIME         8.25

 2 COMBINED AT
+                   R103     301.15      1    FLOW        8494.
                                              TIME        11.75

ROUTED TO
+               R105-104     301.15      1    FLOW        8471.
                                              TIME        13.50

HYDROGRAPH AT
```

+	B104	21.08	1	FLOW TIME	495. 7.25
2 COMBINED AT +	R105+B10	322.23	1	FLOW TIME	8659. 13.50
HYDROGRAPH AT +	B100	21.99	1	FLOW TIME	1239. 6.25
ROUTED TO +	R100-101	21.99	1	FLOW TIME	1181. 10.50
HYDROGRAPH AT +	B101	21.66	1	FLOW TIME	1152. 5.75
2 COMBINED AT +	R100-101	43.65	1	FLOW TIME	1892. 9.25
ROUTED TO +	R101-102	43.65	1	FLOW TIME	1854. 12.25
HYDROGRAPH AT +	B102	17.96	1	FLOW TIME	806. 8.25
2 COMBINED AT +	R101-102	61.61	1	FLOW TIME	2429. 11.50
ROUTED TO +	R102-103	61.61	1	FLOW TIME	2408. 14.50
HYDROGRAPH AT +	B103	16.22	1	FLOW TIME	535. 6.75
2 COMBINED AT +	R102-103	77.83	1	FLOW TIME	2550. 14.00
ROUTED TO +	R103-104	77.83	1	FLOW TIME	2539. 17.00
HYDROGRAPH AT +	B104	10.86	1	FLOW TIME	260. 7.50
HYDROGRAPH AT +	B105	3.19	1	FLOW TIME	71. 6.50
3 COMBINED AT +	R104-105	91.88	1	FLOW TIME	2584. 17.00
ROUTED TO +	R105-106	91.88	1	FLOW TIME	2574. 19.25
HYDROGRAPH AT +	B106	3.93	1	FLOW TIME	78. 6.50
2 COMBINED AT +	R105-106	95.81	1	FLOW TIME	2579. 19.25
2 COMBINED AT +	Comtotal	418.04	1	FLOW TIME	10149. 14.25

*** NORMAL END OF HEC-1 ***

Design By: JG
Check By: EH
Date: 11/14/06

HEC-1 MODEL PREDICTIONS FOR BEATTY WASH AND AMARGOSA WASH

Location	Drainage Area sq miles	DARF	p-24 at design point inches	100-yr HEC-1 Peak cfs
	21.99	0.815	4.19	3408.0
	43.56	0.720	4.15	4172.0
	61.61	0.700	3.35	5227.0
	77.83	0.670	2.94	5130.0
	91.88	0.640	2.77	4813.0
2-8'x5'BCB	95.81	0.630	2.63	4698.0
	42.00	0.730	3.10	2861.0
	83.30	0.670	3.89	6774.0
	113.00	0.610	3.43	5920.0
	196.00	0.550	3.43	9608.0
	271.00	0.515	2.89	10497.0
	301.00	0.495	2.89	10287.0
140' SPAN BRIDGE	322.00	0.485	2.89	10077.0

a= 1.76598 58.34
b= 0.84865
c= 1.051818
Log Q = a + b Log A + c Log P
Q=58.34 A^0.849 * (darf*P24)^1.052
r square= 0.973

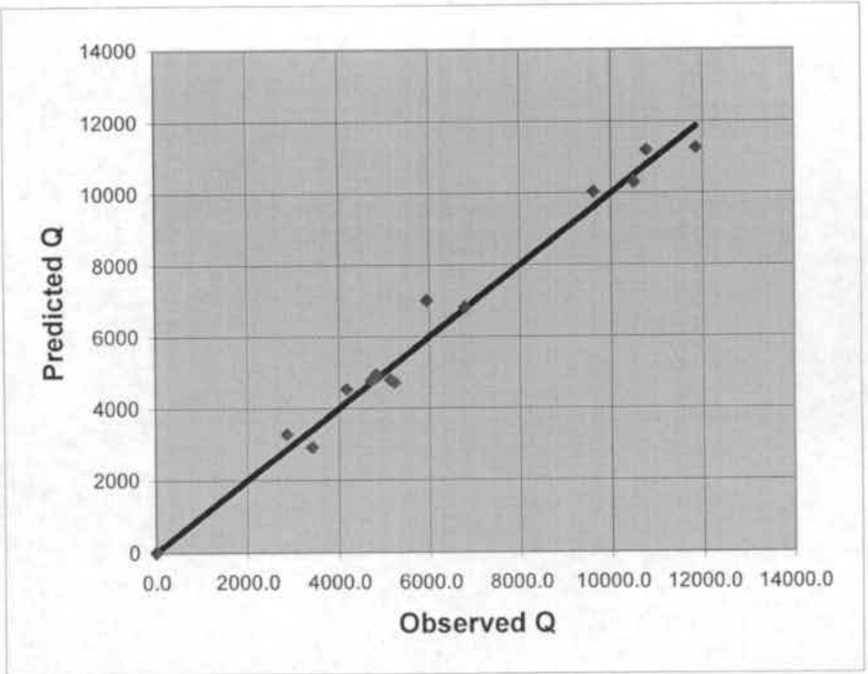
PREDICTION BY REGRESSION EQUATION FOR BEATTY WASH AND AMARGOSA WASH

Tributary Area Miles^2	Area P P24*Darf inch	Log A	Log P	Predicted Log Q by Regression cfs	Predicted Q by Regression cfs
0.00					0
21.99	3.41	1.34	0.53	3.5	2923.6
43.56	2.99	1.64	0.48	3.7	4535.4
61.61	2.34	1.79	0.37	3.7	4718.4
77.83	1.97	1.89	0.29	3.7	4794.7
91.88	1.77	1.96	0.25	3.7	4944.2
95.81	1.66	1.98	0.22	3.7	4763.3
42.00	2.26	1.62	0.35	3.5	3285.6
83.30	2.61	1.92	0.42	3.8	6815.8
113.00	2.09	2.05	0.32	3.8	7007.5
196.00	1.89	2.29	0.28	4.0	10028.7
271.00	1.49	2.43	0.17	4.0	10289.0
301.00	1.49	2.48	0.17	4.1	11247.8
322.00	1.40	2.51	0.15	4.0	11181.7

Design By: JG
Check By: EH
Date: 11/14/06

REGRESSION ANALYSIS FOR BEATTY WASH AND AMARGOSA WASH

Tributary Area Miles^2	Area P P24*Darf inch	Predicted Q-100 by Hec-1 cfs	Log A	Log P	Log Q	Predicted Log Q by Regression cfs	Predicted Q by Regression cfs
0.00		0.0					0
21.99	3.41	3408.0	1.34	0.53	3.53	3.5	2923.6
43.56	2.99	4172.0	1.64	0.48	3.62	3.7	4535.4
61.61	2.34	5227.0	1.79	0.37	3.72	3.7	4718.4
77.83	1.97	5130.0	1.89	0.29	3.71	3.7	4794.7
91.88	1.77	4813.0	1.96	0.25	3.68	3.7	4944.2
95.81	1.66	4698.0	1.98	0.22	3.67	3.7	4763.3
42.00	2.26	2861.0	1.62	0.35	3.46	3.5	3285.6
83.30	2.61	6774.0	1.92	0.42	3.83	3.8	6815.8
113.00	2.09	5939.0	2.05	0.32	3.77	3.8	7007.5
196.00	1.89	9611.0	2.29	0.28	3.98	4.0	10028.7
271.00	1.49	10497.0	2.43	0.17	4.02	4.0	10289.0
301.00	1.49	11851.0	2.48	0.17	4.07	4.1	11247.8
322.00	1.40	10767.0	2.51	0.15	4.03	4.0	11181.7



USGS 10251218 Amargosa River at Hwy 95 below Beatty, NV

Top of Form

Available data for this site	Surface-water: Peak streamflow	1025 USGS GO

Bottom of Form

Nye County, Nevada
Hydrologic Unit Code 18090202
Latitude 36°52'52", Longitude 116°45'04" NAD27
Drainage area 470 square miles
Gage datum 3,200. feet above sea level NGVD29

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1991	Mar. 21, 1991		18.0
1994	1994		0.00
1995	Mar. 11, 1995	3.20	1,100

Surface Water for Nevada: Peak Streamflow

USGS 10251215 Beatty Wash near Beatty, NV

Top of Form

Available data for this site	Surface-water: Peak streamflow	1025 USGS GO

Bottom of Form

Nye County, Nevada
Hydrologic Unit Code 18090202
Latitude 36°56'37", Longitude 116°43'09" NAD27
Drainage area 94.6 square miles
Gage datum 3,460. feet above sea level NGVD29

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1989	Aug. 11, 1989	2.57	25.0

1990	Jul. 14, 1990	3.50	300
1994	1994		0.00
1995	Mar. 11, 1995	4.30	900
1998	Feb. 23, 1998		30

USGS 10251215 Beatty Wash near Beatty, NV

Top of Form

Available data for this site Surface-water: Peak streamflow 1025 USGS GO

Bottom of Form

Nye County, Nevada
Hydrologic Unit Code 18090202
Latitude 36°56'37", Longitude 116°43'09" NAD27
Drainage area 94.6 square miles
Gage datum 3,460. feet above sea level NGVD29

Water Year	Date	Gage Height (feet)	Streamflow (cfs)
1989	Aug. 11, 1989	2.57	25.0
1990	Jul. 14, 1990	3.50	300
1994	1994		0.00
1995	Mar. 11, 1995	4.30	900
1998	Feb. 23, 1998		30

Bottom of Form

USGS 10251220 Amargosa R nr Beatty, NV

Top of Form

Available data for this site Surface-water: Peak streamflow 1025 USGS GO

Bottom of Form

Nye County, Nevada Hydrologic Unit Code 18090202 Latitude 36°52'01.76", Longitude 116°45'37.53" NAD83 Drainage area 470 square miles Gage datum 2,830. feet above sea level NGVD29	**Output formats** Table Graph Tab-separated file WATSTORE formatted file Reselect output format

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)	Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1964	Jul. 26, 1964		25.0	1976	Feb. 1976	0.83	100
1965	Sep. 07, 1965		20.0	1977	Jun. 1977		1.70
1966	1966		0.00	1978	Mar. 04, 1978	3.00	650
1967	Aug. 30, 1967		4,220	1979	1979		0.00
1968	Feb. 10, 1968		90.0	1980	1980		0.00
1969	Feb. 24, 1969		16,000	1981	1981		0.00
1970	Aug. 15, 1970		0.10	1983	Mar. 03, 1983		120
1971	1971		0.00	1991	Mar. 21, 1991		15.0[2]
1972	1972		0.00	1992	Mar. 30, 1992	0.59	12.0[2]
1973	Feb. 11, 1973	1.06	18.0	1993	Feb. 27, 1993		10.0[2]
1974	1974		0.00	1994	1994		0.00
1975	Sep. 10, 1975	1.65	412	1995	Mar. 11, 1995	2.88	1,300
				2000	Aug. 30, 2000		40[2]

Peak Streamflow Qualification Codes.

- 2 -- Discharge is an Estimate

USGS 10249180 Saulsbury Wash nr Tonopah, NV

Top of Form

Available data for this site Surface-water: Peak streamflow 1024 USGS GO

Bottom of Form

Nye County, Nevada Hydrologic Unit Code 16060011 Latitude 38°07'30", Longitude 116°48'30"	**Output formats** Table

NAD27 Drainage area 56 square miles Gage datum 5,800.00 feet above sea level NGVD29	Graph Tab-separated file WATSTORE formatted file Reselect output format

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)	Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1962	Jun. 15, 1962		10.0	1978	Mar. 1978	4.33	120
1963	1963		0.00	1979	1979	2.10	9.00
1964	1964		0.00	1980	1980		0.00
1965	1965		0.00	1981	1981		0.00
1966	Mar. 1966	3.22	41.0	1985	1985		0.00
1967	Jul. 30, 1967	2.83	10.0	1987	1987		0.00
1968	Nov. 20, 1967	1.73	2.00	1988	1988		0.00
1969	Mar. 27, 1969	4.56	340	1989	1989		0.00
1970	Aug. 1970		2.00	1990	1990	1.15	0.50[2]
1971	1971		0.00	1991	1991		0.00[2]
1972	Jun. 06, 1972	3.03	27.0	1992	Jul. 11, 1992	4.63	100[2]
1973	Oct. 04, 1972		3.00	1993	1993		0.00
1974	1974		0.00	1994	Jul. 22, 1994	1.69	0.50[2]
1975	1975		0.10	1995	Mar. 11, 1995	2.09	2.00[2]
1976	Aug. 01, 1976	4.44	90.0	1996	1996		
1977	1977		0.00	1997	1997		
				1998	1998		

Peak Streamflow Qualification Codes.

- 2 -- Discharge is an Estimate

USGS 10249180 Saulsbury Wash nr Tonopah, NV

Top of Form

Available data for this site Surface-water: Peak streamflow 1024 USGS GO

Bottom of Form

Nye County, Nevada	**Output formats**

Hydrologic Unit Code 16060011 Latitude 38°07'30", Longitude 116°48'30" NAD27 Drainage area 56 square miles Gage datum 5,800.00 feet above sea level NGVD29	Table Graph Tab-separated file WATSTORE formatted file Reselect output format

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1962	Jun. 15, 1962		10.0
1963	1963		0.00
1964	1964		0.00
1965	1965		0.00
1966	Mar. 1966	3.22	41.0
1967	Jul. 30, 1967	2.83	10.0
1968	Nov. 20, 1967	1.73	2.00
1969	Mar. 27, 1969	4.56	340
1970	Aug. 1970		2.00
1971	1971		0.00
1972	Jun. 06, 1972	3.03	27.0
1973	Oct. 04, 1972		3.00
1974	1974		0.00
1975	1975		0.10
1976	Aug. 01, 1976	4.44	90.0
1977	1977		0.00
1978	Mar. 1978	4.33	120
1979	1979	2.10	9.00
1980	1980		0.00
1981	1981		0.00
1985	1985		0.00
1987	1987		0.00
1988	1988		0.00
1989	1989		0.00
1990	1990	1.15	0.50[2]
1991	1991		0.00[2]
1992	Jul. 11, 1992	4.63	100[2]
1993	1993		0.00
1994	Jul. 22, 1994	1.69	0.50[2]
1995	Mar. 11, 1995	2.09	2.00[2]
1996	1996		
1997	1997		
1998	1998		

Peak Streamflow Qualification Codes.

- 2 -- Discharge is an Estimate

USGS 10249135 San Antonio Wash tr nr Tonopah, NV

Top of Form

Available data for this site	Surface-water: Peak streamflow	1024 USGS GO

Bottom of Form

Nye County, Nevada
Hydrologic Unit Code 16060011
Latitude 38°19'37", Longitude 117°07'25"
NAD27
Drainage area 3.42 square miles
Gage datum 6,030.00 feet above sea level
NGVD29

Output formats

- Table
- Graph
- Tab-separated file
- WATSTORE formatted file
- Reselect output format

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1965	1965		1.00
1966	1966		0.00
1967	Jul. 13, 1967	2.83	4.00
1968	Jul. 31, 1968		1.00
1969	Jul. 1969	2.93	2.00
1970	Aug. 1970	4.02	22.0
1971	Sep. 1971		0.10
1972	Aug. 13, 1972	9.65	660
1973	Oct. 04, 1972	3.00	7.00

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1974	1974		0.00
1975	1975		0.00
1976	1976		0.00
1977	Aug. 1977		1.00
1978	1978		0.00
1979	1979		0.20
1980	1980		0.00
1981	1981		0.00
1982	1982		0.00
1984	Aug. 14, 1984		130

Appendix V: Jackson Wash Hec-1 Model Output and Hydraulic Capacity Estimation

Design By: JG
Check By: EH
Date: 11/14/06

Watershed Parameters

Watrershed Area	Subarea ID	Area sq mile	Upst Elev ft	Dnst Elev ft	Lenght of Waterway mile	Length to Centroid Mile	Waterway Slope percent	Waterway Slope ft/mile	Curve Number	Roughness Kn	USBR Lag Time hours	Precip 100yr24hr inch
Jackson Wash (tributary area to existing culvert)	100.00	126.87	2200.00	1500.00	29.36	14.68	0.45	23.85	77.00	0.050	4.39	3.40
	101.00	29.64	2000.00	1500.00	21.59	10.80	0.44	23.16	77.00	0.050	3.60	3.25
	102.00	7.55	1600.00	1500.00	9.09	4.55	0.21	11.00	77.00	0.050	2.30	2.94
	103.00	13.59	1750.00	1450.00	6.82	3.41	0.83	44.00	77.00	0.050	1.51	2.93
	104.00	10.35	1750.00	1400.00	11.55	5.78	0.57	30.30	77.00	0.050	2.28	2.83
	105.00	11.96	1650.00	1400.00	21.59	10.80	0.22	11.58	77.00	0.050	4.03	2.93
	106.00	164.25	2200.00	1600.00	23.54	11.77	0.48	25.49	77.00	0.050	3.75	3.36
	Total	364.21										

REACH			GIS DATA				DATA			Derived					
Reach ID	From	to	Length ft	Upstream Elev ft	Downst Elev ft		Slope ft/ft	Roughness	Depth ft	Velocity fps	K hour	X	N	Low limit 1/(2(1-X)	K/(N*dT) < and <	Hi limit 1/2X
1	100	101	12000.0	1510.0	1500.0		0.0008	0.050	1.00	0.86	3.87	0.10	20.00	0.56	2.32	5.00
2	101	103	60000.0	1500.0	1450.0		0.0008	0.050	1.00	0.86	19.37	0.10	60.00	0.56	3.87	5.00
3	103	104	42000.0	1450.0	1400.0		0.0012	0.050	1.00	1.03	11.35	0.10	40.00	0.56	3.40	5.00
4	106	102	50000.0	1600.0	1500.0		0.0020	0.050	1.00	1.33	10.42	0.10	40.00	0.56	3.13	5.00

```
1*****************************************                ****************************************
*                                       *                *                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                *   U.S. ARMY CORPS OF ENGINEERS       *
*             JAN   1997                *                *   HYDROLOGIC ENGINEERING CENTER      *
*          VERSION 4.1                  *                *         609 SECOND STREET            *
*                                       *                *       DAVIS, CALIFORNIA 95616        *
*   RUN DATE   12DEC06   TIME  09:14:43 *                *          (916) 756-1104              *
*                                       *                *                                      *
*****************************************                ****************************************


                    X      X  XXXXXXX   XXXXX          X
                    X      X  X        X     X        XX
                    X      X  X        X               X
                    XXXXXXX   XXXX     X        XXXXX  X
                    X      X  X        X               X
                    X      X  X        X     X         X
                    X      X  XXXXXXX   XXXXX         XXX


THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1                                      HEC-1 INPUT                                         PAGE  1

     LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

                 *DIAGRAM
        1        ID
        2        ID      24-hr GENERAL STORM
        3        ID      ************************************************************
        4        ID      *  ALL AREAS of     sq miles                                  *
        5        ID      *                                                             *
        6        ID      ************************************************************
        7        ID
        8        ID      24-hr 100-year event-- GENERAL Storm
        9        ID      prepared by PB-Water Division for Caliente Railroad Route Study
       10        ID
       11        ID      This is the model for Goldfield Area, Nevada
       12        ID
       13        ID      PREC  0.832 0.770 0.620 0.590 0.550 0.470
       14        ID      AREA    7.51 27.0  129.0 164.0 199.7 364.2
*** FREE ***
       15        IT      15       0       0     250
       16        IO       5       0       0
       17        IN      15       0       0
       18        JR     PREC   0.832    0.77    0.62    0.59    0.55    0.47

       19        KK     B100
       20        KM    Subarea 100
       21        BA   126.87
       22        PB     3.40
       23        PC     .000    .026    .051    .076    .101    .125    .149    .172    .195    .218
       24        PC     .240    .262    .283    .304    .324    .345    .364    .384    .403    .421
       25        PC     .440    .457    .475    .492    .508    .525    .541    .556    .571    .586
       26        PC     .601    .615    .628    .642    .655    .667    .680    .692    .703    .714
       27        PC     .725    .736    .746    .756    .766    .775    .785    .793    .802    .810
       28        PC     .818    .826    .833    .840    .847    .854    .860    .866    .872    .878
       29        PC     .883    .887    .894    .899    .903    .908    .912    .916    .921    .924
       30        PC     .928    .932    .935    .939    .942    .945    .948    .951    .954    .957
       31        PC     .960    .962    .965    .968    .971    .973    .976    .979    .982    .984
       32        PC     .987    .990    .993    .996    .999    1.00
       33        LS        0      77
       34        UD     4.39

       35        KK    100-J
       36        KM    Route from Basn 1000 to J
       37        RM     20.0    3.87    0.10

       38        KK     B101
       39        KM    Subarea 101
       40        BA    29.64
       41        PB     3.25
       42        LS        0      77
       43        UD     3.60

       44        KK     B106
       45        KM    Subarea 106
       46        BA   164.25
       47        PB     3.36
       48        LS        0      77
       49        UD     3.75
1                                      HEC-1 INPUT                                         PAGE  2

     LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


       50        KK    P-102
       51        KM    Route from P to 102
       52        RM     40.0   10.42    0.10

       53        KK     B102
       54        KM    Subarea 102
       55        BA     7.55
       56        PB     2.94
       57        LS        0      77
       58        UD     2.30

       59        KK        P
       60        KM    Combine Subarea 106 to 102
       61        HC        2
```

```
          62          KK         J
          63          KM    At J to combine Subareas 100, 101,and 102
          64          HC        3

          65          KK    J-103
          66          KM    Route from J to 103
          67          RM     60.0   19.37    0.10

          68          KK     B103
          69          KM    Subarea 103
          70          BA    13.59
          71          PB     2.93
          72          LS        0       77
          73          UD     1.51

          74          KK         H
          75          KM    At H to combine Subareas J and 103
          76          HC        2

          77          KK    H-104
          78          KM    Route from J to 1043
          79          RM     40.0   11.35    0.10

          80          KK     B105
          81          KM    Subarea 105
          82          BA    11.96
          83          PB     2.93
          84          LS        0       77
          85          UD     4.03

          86          KK     B104
          87          KM    Subarea 104
          88          BA     10.0
          89          PB     2.83
          90          LS        0       77
          91          UD     2.28
1                                          HEC-1 INPUT                                      PAGE  3

        LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


          92          KK         F
          93          KM    At F to combine all Subareas
          94          HC        3
          95          ZZ
1
              SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
 LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

  NO.      (.) CONNECTOR         (<---) RETURN OF DIVERTED OR PUMPED FLOW

   19        B100
               V
               V
   35       100-J
               .
   38          .        B101
               .          .
   44          .          .        B106
               .          .          V
               .          .          V
   50          .          .        P-102
               .          .          .
   53          .          .          .        B102
               .          .          .          .
   59          .          .          P...........
               .          .          .
   62          J.......................
               V
               V
   65       J-103
               .
   68          .        B103
               .          .
   74          H...........
               V
               V
   77       H-104
               .
   80          .        B105
               .          .
   86          .          .        B104
               .          .          .
   92          F.......................

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************                    *****************************************
 *                                       *                    *                                       *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                    *     U.S. ARMY CORPS OF ENGINEERS      *
 *              JAN   1997               *                    *     HYDROLOGIC ENGINEERING CENTER     *
 *           VERSION 4.1                 *                    *          609 SECOND STREET            *
 *                                       *                    *       DAVIS, CALIFORNIA 95616         *
 *   RUN DATE   12DEC06  TIME  09:14:43  *                    *            (916) 756-1104             *
 *                                       *                    *                                       *
 *****************************************                    *****************************************
```

```
24-hr GENERAL STORM
*********************************************************************
*  ALL AREAS of      sq miles                                        *
*                                                                    *
*********************************************************************

24-hr 100-year event-- GENERAL Storm
prepared by PB-Water Division for Caliente Railroad Route Study

This is the model for Goldfield Area, Nevada

PREC  0.832 0.770 0.620 0.590 0.550 0.470
AREA   7.51 27.0  129.0 164.0 199.7 364.2

16 IO        OUTPUT CONTROL VARIABLES
                IPRNT          5  PRINT CONTROL
                IPLOT          0  PLOT CONTROL
                QSCAL         0.  HYDROGRAPH PLOT SCALE

  IT         HYDROGRAPH TIME DATA
                 NMIN         15  MINUTES IN COMPUTATION INTERVAL
                IDATE      1   0  STARTING DATE
                ITIME       0000  STARTING TIME
                   NQ        250  NUMBER OF HYDROGRAPH ORDINATES
               NDDATE      3   0  ENDING DATE
               NDTIME       1415  ENDING TIME
                ICENT         19  CENTURY MARK

          COMPUTATION INTERVAL     .25 HOURS
                TOTAL TIME BASE  62.25 HOURS

     ENGLISH UNITS
          DRAINAGE AREA          SQUARE MILES
          PRECIPITATION DEPTH    INCHES
          LENGTH, ELEVATION      FEET
          FLOW                   CUBIC FEET PER SECOND
          STORAGE VOLUME         ACRE-FEET
          SURFACE AREA           ACRES
          TEMPERATURE            DEGREES FAHRENHEIT

  JP         MULTI-PLAN OPTION
                NPLAN          1  NUMBER OF PLANS

  JR         MULTI-RATIO OPTION
               RATIOS OF PRECIPITATION
              .83      .77      .62      .59      .55      .47
1
```

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES
TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN		RATIO 1 .83	RATIO 2 .77	RATIO 3 .62	RATIO 4 .59	RATIO 5 .55	RATIO 6 .47
HYDROGRAPH AT +	B100	126.87	1	FLOW	5188.	4440.	2780.	2478.	2093.	1395.
				TIME	13.50	13.75	14.50	14.75	15.00	15.50
ROUTED TO +	100-J	126.87	1	FLOW	5144.	4401.	2755.	2456.	2075.	1382.
				TIME	17.50	17.75	18.50	18.50	18.75	19.50
HYDROGRAPH AT +	B101	29.64	1	FLOW	1156.	986.	611.	543.	457.	301.
				TIME	12.50	12.75	13.50	13.75	14.00	14.75
HYDROGRAPH AT +	B106	164.25	1	FLOW	6792.	5807.	3626.	3231.	2727.	1813.
				TIME	12.75	13.00	13.75	13.75	14.00	14.75
ROUTED TO +	P-102	164.25	1	FLOW	6568.	5615.	3505.	3122.	2634.	1749.
				TIME	23.25	23.50	24.25	24.50	24.75	25.50
HYDROGRAPH AT +	B102	7.55	1	FLOW	256.	216.	130.	115.	96.	61.
				TIME	11.00	11.25	12.25	12.50	12.75	13.50
2 COMBINED AT +	P	171.80	1	FLOW	6653.	5689.	3554.	3165.	2671.	1771.
				TIME	23.25	23.50	24.25	24.50	24.75	25.25
3 COMBINED AT +	J	328.31	1	FLOW	11122.	9509.	5938.	5290.	4467.	2972.
				TIME	21.50	21.75	22.50	22.75	23.00	23.75
ROUTED TO +	J-103	328.31	1	FLOW	10526.	9003.	5624.	5010.	4229.	2810.
				TIME	41.00	41.25	42.00	42.25	42.50	43.25
HYDROGRAPH AT +	B103	13.59	1	FLOW	473.	400.	240.	212.	176.	113.
				TIME	9.75	10.00	11.00	11.25	11.50	12.25
2 COMBINED AT +	H	341.90	1	FLOW	10526.	9003.	5624.	5010.	4229.	2810.
				TIME	41.00	41.25	42.00	42.25	42.50	43.25
ROUTED TO +	H-104	341.90	1	FLOW	10270.	8783.	5487.	4887.	4125.	2740.
				TIME	52.50	52.75	53.50	53.50	54.00	54.50
HYDROGRAPH AT +	B105	11.96	1	FLOW	368.	311.	187.	165.	137.	87.
				TIME	13.50	13.75	14.50	14.75	15.00	15.75
HYDROGRAPH AT +	B104	10.00	1	FLOW	312.	263.	157.	138.	115.	72.

				TIME	11.00	11.50	12.25	12.50	12.75	13.50
+	3 COMBINED AT	F	363.86	1	FLOW	10270.	8783.	5487.	4887.	4125.	2740.
					TIME	52.50	52.75	53.50	53.50	54.00	54.50

*** NORMAL END OF HEC-1 ***

Design By: JG
Check By: EH
Date: 11/14/06

RESULTS FOR JACKSON WASH

Using 24-hr General Storm **P24**
SCS CN for desert area **77** **Loss S=** 2.99 **SCS CN for desert area** **85** **Loss S=** 1.76
Difference between CD=85 and CN=77 is considered to be the shallow water detention in the inland basin.
The additional loss (2.99 inch versus 1.76 inch) reflects the surface detention depth of one-ft used in Muskingum Routing

Location	Drainage Area sq miles	DARF	100-yr HEC-1 Peak cfs	CN=85 FEMA Peak cfs	AMC2 Freq-Q Peak cfs	10-yr HEC-1 Peak cfs	CN=85 FEMA Peak cfs	AMC2 Freq-Q Peak cfs	2-yr HEC-1 Peak cfs	Cn=70 FEMA Peak cfs	AMC1 Freq-Q Peak cfs
	27.00	0.770	1054.0								
	129.65	0.620	2841.0								
	164.00	0.590	2778.0								
	199.69	0.550	2275.0								
2-5x10 CBC	363.86	0.47	2740.0								

Footnote: **The existing double 5' x 10' BCB can pass 2463 cfs at y=5 feet with n=0.014, and S=0.01 ft/ft.**
It appears that the upstream inland basin attenuates the peak flow.

Upstream of Culvert (West of SH95)

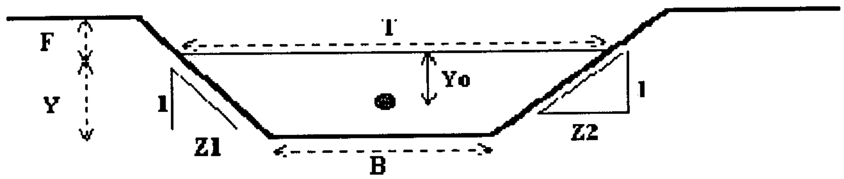
Downstream Culvert (East of SH95)

Inland Basin Storage Volume West of SH95

Inland Basin Storage Volume East of SH95

Normal Flow Analysis - Trapezoidal Channel

Project: Mina Route
Channel ID: Existing double 5x10 RCB on US 95 (capacity estimation) for Jackso



Design Information (Input)			
Channel Invert Slope	So =	0.0100	ft/ft
Channel Manning's N	N =	0.014	
Bottom Width	B =	20.0	ft
Left Side Slope	Z1 =	0.0	ft/ft
Right Side Slope	Z2 =	0.0	ft/ft
Freeboard Height	F =	0.5	ft
Design Water Depth	Y =	**5.00**	ft

Normal Flow Condtion (Calculated)			
Discharge	**Q =**	**2,462.9**	cfs
Froude Number	**Fr =**	**1.94**	
Flow Velocity	**V =**	**24.6**	fps
Flow Area	A =	100.0	sq ft
Top Width	T =	20.0	ft
Wetted Perimeter	P =	30.0	ft
Hydraulic Radius	R =	3.3	ft
Hydraulic Depth	D =	5.0	ft
Specific Energy	Es =	14.4	ft
Centroid of Flow Area	Yo =	2.5	ft
Specific Force	Fs =	133.3	kip

12/13/2006, 2:40 PM

Appendix VI: Equalizer/General Crossings

Design By: JG
Check By: EH
Date: 11/14/06

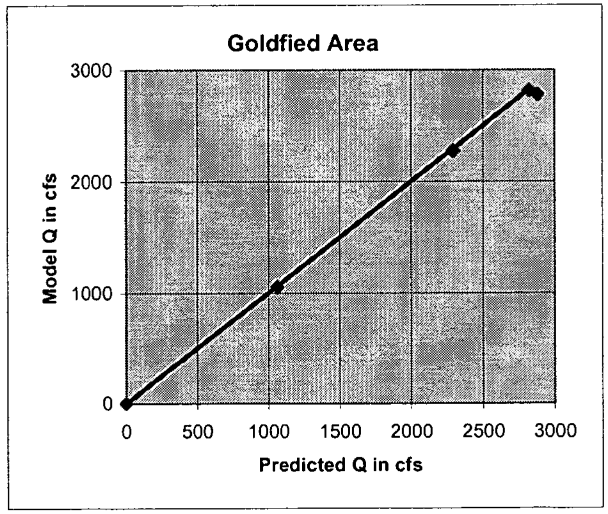
REGRESION ANALYSIS for Area Between Goldfield and Beatty

HEC-1 Predictions

Location	Drainage Area sq miles	DARF	p-24 at design point inches	100-yr HEC-1 Peak cfs
	27.00	0.770	3.25	1054.0
	129.00	0.620	3.40	2815.0
	164.00	0.590	3.25	2778.0
	199.69	0.550	2.83	2275.0

Tributary Area Miles^2	Area P P24*Darf inch	Predicted Q-100 Hec-1 cfs	Log A	Log P	Log Q	Predicted Log Q by Regression cfs	Predicted Q by Regression cfs
0.00		0.0					0
27.00	2.50	1054.0	1.43	0.40	3.02	3.027	1064.1
129.00	2.11	2815.0	2.11	0.32	3.45	3.451	2822.7
164.00	1.92	2778.0	2.21	0.28	3.44	3.460	2883.1
199.69	1.56	2275.0	2.30	0.19	3.36	3.361	2293.7

a= 1.09 12.30
b= 0.83
c= 1.88
Log Q = a + b Log A + c Log P
Q=12.30 A^0.83 * (darf*P24)^1.88
r square= 0.998



PREDICTION by REGRESSION Equation for Inland Basin Area CN=77

Area sq mile	Area Rain Depth P24*Darf inch	Log A	Log P	Log Q	Predcited Q-100 cfs
6.00	2.16	0.78	0.33	2.363	230.7
15.00	2.16	1.18	0.33	2.693	493.6
20.00	2.16	1.30	0.33	2.797	626.8
25.00	2.16	1.40	0.33	2.878	754.3

Double 60-inch pipes under US95 south of Goldfield

Diameter	**5 ft**		
Head Water	**10 ft**		
Orifice Coeff	**0.65**		
Discharge for Single Pipe	**280.49 cfs**	**to drain**	**7.5 sq miles**
Discharge for Two Pipes	**560.98 cfs**	**to drain**	**17.5 sq miles**

Area sq mile	Area Rain Depth P24*Darf inch	Log A	Log P	Log Q	Predcited Q-100 cfs
7.50	2.16	0.88	0.33	2.444	277.7
17.50	2.16	1.24	0.33	2.749	561.0

Single 30-inch pipe under US95 south of Goldfield

Diameter	**2.5 ft**		
Head Water	**3 ft**		
Orifice Coeff	**0.65**		
Discharge for Single Pipe	**33.87 cfs**	**to drain**	**0.6 sq miles**
Discharge for Two Pipes	**67.74 cfs**	**to drain**	**1.35 sq miles**

Area sq mile	Area Rain Depth P24*Darf inch	Log A	Log P	Log Q	Predcited Q-100 cfs
0.60	2.16	-0.22	0.33	1.533	34.1
1.35	2.16	0.13	0.33	1.825	66.9

Appendix VII: Walker River Drainage Basin Hec-1 Model Output and Regression Analyses

Design By: JG
Check By: EH
Date: 4/5/07

WALKER WATERSHED STUDY

SUMMARY

1. Five watersheds were selected for HEC-1 test. (see Sheet: HyInput)
2. The convective 24-hr rainfall distribution (General Storm) was used to generate the 100-year design storm (see Sheet 24RainCv).
3. The SCS unitgragh was used to predict the 100-year runoff hydrographs.
4. The loss function was set to be SCS CN=74 for mountain areas in the desert climate
5. A set of DARF was derived from the data base including (1) rainfall events observed in SW Nevada and (2) rainfall distributions recommended for hydrologic designs. (see Sheet DARF)

DARF Equation

a	0.2356
d	9.6559
b	0.5342
g	420.6984
c	0.2198

$$Darf = ae^{-\frac{A}{d}} + be^{-\frac{A}{g}} + C$$

6. Muskingum routing was used to simulate flood flow movement through alluvial fans (see Sheet HyInput)
7. Based on the HEC-1 result, the regression equation was generated as (See Sheet: Regression for Walker)

REGRESSION MODEL

a	1.0752125	Exp(a)=	11.89
b	0.91523		
c	1.8071937		

Log Q-100 = a + b Log A + c Log (P*Darf)

Equation for Walker Area: **Q=11.89 A^0.91523 (P*Darf)^1.8072** R-square= 0.962

Design By: JG
Check By: EH
Date: 4/5/07

8. Frequency analyses were conducted for three selected USGS gage stream gages:

USGS 10297500 W WALKER R AT HOYE BRIDGE NR WELLINGTON, NV	450 sq miles
USGS 10299100 DESERT CREEK NEAR WELLINGTON, NV	947 sq miles
USGS 10300000 W WALKER R NR HUDSON, NV	50.4 sq miles

The records indicate that these three watersheds had flow diversion throughout the recording periods.

In comparison, the predictions by the regression equation are almost twice that by frequency analysis
The storm centering tests imply that the critical storm cover area is 500 square miles.

9. A regression analysis was also conducted for the entire Mina Rail Route area, including
(1) Betty area (Betty Wash and Amargosa Wash) (2) Goldfield area (Jackson Wash), and
(3) Walker area (five sample watersheds)

Results are: (see Sheet: Regression for All)

a= 1.6625463 Exp(a)= 45.98
b= 0.8238364
c= 1.0552843

Log Q-100 = a + b Log A + c Log (P*Darf)

Equation for All Rotue **Q=45.98 * A^0.8238 * (P*Darf)^1.0553** R-square= 0.864

10. Conlcusion
Walker area is covered by mountains in the deseart climate. A high hydrologic loss was expected (CN=74).
Due to the high elevation, the 24-hr precipitation in the Walker area is 50% higher that that in the Betty area
The Betty area is dominated by convective storm, and the Walker area is under the general storm.
Two regression equations were produced separately for Walker and Betty areas.
Equation for All carries a lower correlation coefficient
Equation for All tends to predict higher peak flows for the Walker Area.

Design By: JG
Check By: EH
Date: 4/5/07

SELECTED SAMPLE WATERSHEDS IN WALKER LAKE AREA FOR HEC-1 MODELING TESTS

CHIATOVICH

Watrershed Area	Subarea ID	Area sq mile	Upst Elev ft	Dnst Elev ft	Lenght of Waterway mile	Length to Centroid Mile	Waterway Slope percent	Waterway Slope ft/mile	Curve Number	Roughness Kn	USBR Lag Time hours	Precip 100yr24hr inch
CHIATOVICH	100.00	12.67			4.00	2.00	3.00	158.40	74.00	0.050	0.86	5.50
	101.00	7.96			3.20	1.60	3.00	158.40	74.00	0.050	0.74	5.00
	102.00	3.14			2.70	1.35	3.00	158.40	74.00	0.050	0.66	4.25
	Total	23.77										

REACH			GIS DATA							DATA	Derived					
Reach ID	From	to	Length ft	Upstream Elev ft	Downst Elev ft		Slope ft/ft	Roughness	Depth ft	Velocity fps	K hour	X	N	Low limit 1/(2(1-X)	K/(N*dT) < and <	Hi limit 1/2X
100	100	101	16896.0				0.0300	0.050	0.50	3.24	1.45	0.10	5.00	0.56	3.47	5.00
101	101	102	14256.0				0.0300	0.050	0.50	3.24	1.22	0.10	5.00	0.56	2.93	5.00

REESE

Watrershed Area	Subarea ID	Area sq mile	Upst Elev ft	Dnst Elev ft	Lenght of Waterway mile	Length to Centroid Mile	Waterway Slope percent	Waterway Slope ft/mile	Curve Number	Roughness Kn	USBR Lag Time hours	Precip 100yr24hr inch
REESE	100.00	5.66			3.50	1.75	3.00	158.40	74.00	0.050	0.79	5.00
	101.00	4.16			3.00	1.50	3.00	158.40	74.00	0.050	0.71	4.75
	102.00	3.23			3.00	1.50	3.00	158.40	74.00	0.050	0.71	3.75
	Total	13.05										

REACH			GIS DATA							DATA	Derived					
Reach ID	From	to	Length ft	Upstream Elev ft	Downst Elev ft		Slope ft/ft	Roughness	Depth ft	Velocity fps	K hour	X	N	Low limit 1/(2(1-X)	K/(N*dT) < and <	Hi limit 1/2X
100	100	101	15840.0				0.0300	0.050	0.50	3.24	1.36	0.10	5.00	0.56	3.26	5.00
101	101	102	15840.0				0.0300	0.050	0.50	3.24	1.36	0.10	5.00	0.56	3.26	5.00

Desert

10299100 DESERT CREEK NEAR WELLINGTON, NV

Watrershed Area	Subarea ID	Area sq mile	Upst Elev ft	Dnst Elev ft	Lenght of Waterway mile	Length to Centroid Mile	Waterway Slope percent	Waterway Slope ft/mile	Curve Number	Roughness Kn	USBR Lag Time hours	Precip 100yr24hr inch
Desert	100.00	14.92			6.50	3.25	3.00	158.40	74.00	0.050	1.19	6.50
	101.00	6.52			7.00	3.50	3.00	158.40	74.00	0.050	1.25	6.50
	102.00	10.22			5.50	2.75	3.00	158.40	74.00	0.050	1.06	6.25
	103.00	9.16			5.30	2.65	3.00	158.40	74.00	0.050	1.04	5.75
	Total	40.82										

REACH			GIS DATA							DATA	Derived					
Reach ID	From	to	Length ft	Upstream Elev ft	Downst Elev ft		Slope ft/ft	Roughness	Depth ft	Velocity fps	K hour	X	N	Low limit 1/(2(1-X)	K/(N*dT) < and <	Hi limit 1/2X
100	100	101	36960.0				0.0300	0.050	0.50	3.24	3.16	0.10	5.00	0.56	7.60	5.00
101	101	102	10560.0				0.0300	0.050	0.50	3.24	0.90	0.10	5.00	0.56	2.17	5.00
101	102	103	27984.0				0.0300	0.050	0.50	3.24	2.40	0.10	8.00	0.56	3.59	5.00

Hoye Bridge

10297500 W WALKER R AT HOYE BRIDGE NR WELLINGTON, NV

Watrershed Area	Subarea ID	Area sq mile	Upst Elev ft	Dnst Elev ft	Lenght of Waterway mile	Length to Centroid Mile	Waterway Slope percent	Waterway Slope ft/mile	Curve Number	Roughness Kn	USBR Lag Time hours	Precip 100yr24hr inch
Hoye Bridge	100.00	181.20			18.50	9.25	3.00	158.40	74.00	0.050	2.37	6.50
	101.00	93.22			10.00	5.00	3.00	158.40	74.00	0.050	1.58	6.00
	102.00	184.18			16.00	8.00	3.00	158.40	74.00	0.050	2.15	4.00
	103.00	61.02			9.00	4.50	3.00	158.40	74.00	0.050	1.47	5.00
	Total	458.60										

REACH			GIS DATA							DATA	Derived					
Reach ID	From	to	Length ft	Upstream Elev ft	Downst Elev ft		Slope ft/ft	Roughness	Depth ft	Velocity fps	K hour	X	N	Low limit 1/(2(1-X)	K/(N*dT) < and <	Hi limit 1/2X
100	100	101	52800.0				0.0300	0.050	0.50	3.24	4.52	0.10	15.00	0.56	3.62	5.00
101	101	102	84480.0				0.0300	0.050	0.50	3.24	7.23	0.10	25.00	0.56	3.47	5.00
101	102	103	10560.0				0.0300	0.050	0.50	3.24	0.90	0.10	3.00	0.56	3.62	5.00

Sweetwater

10293048 SWEETWATER CK AT HWY 338 AB MTH NR BRIDGEPORT, CA

Watrershed Area	Subarea ID	Area sq mile	Upst Elev ft	Dnst Elev ft	Lenght of Waterway mile	Length to Centroid Mile	Waterway Slope percent	Waterway Slope ft/mile	Curve Number	Roughness Kn	USBR Lag Time hours	Precip 100yr24hr inch
Sweetwater	100.00	181.18			20.00	10.00	3.00	158.40	74.00	0.050	2.49	5.00
	101.00	158.07			21.00	10.50	3.00	158.40	74.00	0.050	2.57	6.00
	102.00	141.03			12.00	6.00	3.00	158.40	74.00	0.050	1.78	4.00
	Total	480.28										

REACH			GIS DATA							DATA	Derived					
Reach ID	From	to	Length ft	Upstream Elev ft	Downst Elev ft		Slope ft/ft	Roughness	Depth ft	Velocity fps	K hour	X	N	Low limit 1/(2(1-X)	K/(N*dT) < and <	Hi limit 1/2X
100	100	101	63360.0				0.0300	0.050	0.50	3.24	5.43	0.10	20.00	0.56	3.26	5.00

Design By: JG
Check By: EH
Date: 4/5/07

REGRESSION MODEL for Q-100

a	1.075213	Exp(a)=	11.89
b	0.91523		
c	1.807194		

Log Q-100 = a + b Log A + c Log (P*Darf)
Q=exp(a) * A^b * (P*Darf)^c
R-square 0.963

DARF Equation

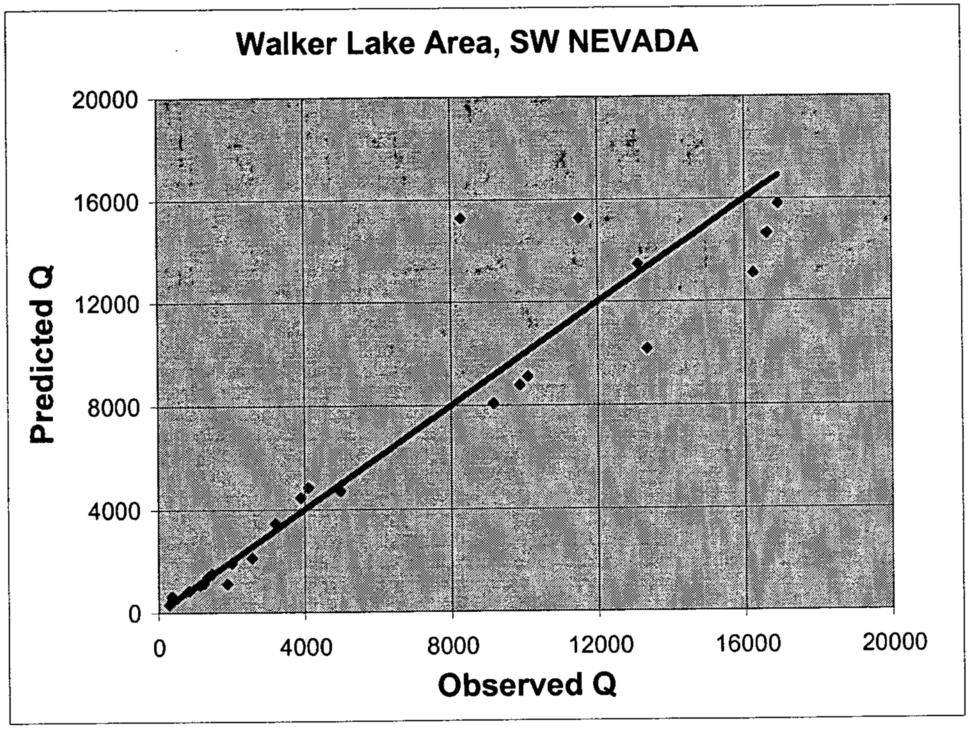
a	0.2356
d	9.6559
b	0.5342
g	420.6984
c	0.2198

$$Darf = ae^{-\frac{A}{d}} + be^{-\frac{A}{g}} + C$$

PREDICTION BY REGRESSION EQUATION FOR Walker Lake AREA

Location	Drainage Area A sq miles	Point P-100 P inch	DARF	100-yr HEC-1 Peak cfs	Log A	Log (P*Darf)	Log Q	Predicted Q-100 by Regression cfs	Predicted Q-100 by Log-Prsn cfs	
Chiatovich	3.1	5.50	0.920	377.0	0.497	0.704	2.576	635.0		
	8.0	5.00	0.847	1130.0	0.901	0.627	3.053	1078.8		
	12.7	4.25	0.802	1881.0	1.103	0.532	3.274	1113.3		
	23.8	4.75	0.745	2554.0	1.376	0.549	3.407	2119.7		
Reese	3.2	3.75	0.919	303.00	0.509	0.537	2.481	325.1		
	5.7	5.00	0.878	834.00	0.753	0.642	2.921	841.9		
	9.8	4.75	0.827	1236.00	0.992	0.594	3.092	1140.2		
	13.1	4.75	0.799	1336.00	1.116	0.579	3.126	1389.2		
Hoye	61.0	5.00	0.682	4963.0	1.785	0.533	3.696	4704.7		
	93.2	6.00	0.648	9877.0	1.970	0.590	3.995	8777.9		
	181.2	6.50	0.567	16619.0	2.258	0.567	4.221	14651.0		
	274.4	6.25	0.498	16913.0	2.438	0.493	4.228	15783.8		
	458.6	5.90	0.399	11518.0	2.661	0.372	4.061	15270.9		
	519.6	5.90	0.375	8287.0	2.716	0.345	3.918	15288.5		
Desert	6.5	6.50	0.866	1459.0	0.813	0.750	3.164	1497.7		
	10.2	6.25	0.823	2006.0	1.009	0.711	3.302	1922.7		
	21.4	6.50	0.753	3193.0	1.330	0.690	3.504	3463.7		
	31.7	6.37	0.724	3889.0	1.501	0.664	3.590	4451.5		
	40.8	6.00	0.708	4103.0	1.611	0.628	3.613	4840.5		
Sweetwater	141.0	5.00	0.602	9152.0	2.149	0.479	3.962	8072.6		
	158.0	5.50	0.587	13344.0	2.199	0.509	4.125	10164.4		
	181.0	5.00	0.567	10095.0	2.258	0.453	4.004	9114.6		
	339.5	5.50	0.458	16245.0	2.531	0.401	4.211	13091.1		
	480.0	5.50	0.391	13110.0	2.681	0.332	4.118	13464.6		
GS10300000	50.0	4.25	0.696		1.699	0.471		3025.6	**436**	Walker
GS10297500	450.0	5.50	0.403		2.653	0.346		13442.9	**7775.0**	Walker
GS10299100	967.0	5.50	0.273		2.985	0.177		13426.8	**4830.0**	Walker

Design By: JG
Check By: EH
Date: 4/5/07



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*                                     *                    *                                     *
*   OOD HYDROGRAPH PACKAGE  (HEC-1)   *                    *   U.S. ARMY CORPS OF ENGINEERS      *
*             JAN   1997              *                    *   HYDROLOGIC ENGINEERING CENTER     *
*          VERSION 4.1                *                    *         609 SECOND STREET           *
*                                     *                    *      DAVIS, CALIFORNIA 95616        *
*  RUN DATE   17MAR07  TIME  09:25:28 *                    *          (916) 756-1104             *
*                                     *                    *                                     *
***************************************                    ***************************************


                     X     X  XXXXXXX   XXXXX          X
                     X     X  X        X     X        XX
                     X     X  X        X               X
                     XXXXXXX  XXXX     X       XXXXX   X
                     X     X  X        X               X
                     X     X  X        X     X         X
                     X     X  XXXXXXX   XXXXX         XXX


    THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

    THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
    THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
    NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
    DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
    KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1                                         HEC-1 INPUT                                          PAGE  1

       LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

                 *DIAGRAM
         1       ID
         2       ID
         3       ID     ***************************************************************
         4       ID     *  ALL AREAS of 23.77 sq miles                                *
         5       ID     *  Chiatovich near Walker Lake                        *
         6       ID     ***************************************************************
         7       ID
         8       ID     24-hr 100-year event-- Convective Storm
         9       ID     prepared by PB-Water Division for Mina Railroad Route Study
        10       ID
        11       ID     PREC     .927 .863 .816 .745
        12       ID     AREA      3.1  8.0 12.7 23.8
 *** FREE ***
        13       IT      15       0       0     250
        14       IO       5       0       0
        15       IN      15       0       0
        16       JR     PREC      1   0.927   0.863   0.816   0.745

        17       KK    B100
        18       KM    Subarea 100
        19       BA    12.67
        20       PB     5.50
        21       PC     .000    .044    .087    .128    .168    .206    .243    .279    .313    .346
        22       PC     .378    .408    .437    .465    .492    .518    .543    .567    .589    .611
        23       PC     .632    .652    .671    .689    .706    .722    .738    .753    .767    .780
        24       PC     .793    .805    .816    .827    .837    .846    .855    .864    .872    .879
        25       PC     .886    .892    .898    .904    .909    .914    .919    .923    .927    .931
        26       PC     .934    .937    .940    .943    .945    .947    .949    .951    .952    .954
        27       PC     .956    .957    .958    .959    .960    .961    .962    .963    .964    .965
        28       PC     .966    .967    .968    .969    .969    .970    .971    .972    .974    .975
        29       PC     .976    .977    .978    .980    .982    .983    .985    .987    .989    .991
        30       PC     .993    .995    .996    .997    .998    1.00
        31       LS        0      74
        32       UD     0.86

        33       KKR100-101
        34       KM    Route from 100 to 101
        35       RM      5.0    1.45    0.10

        36       KK    B101
        37       KM    Subarea 101
        38       BA     7.96
        39       PB      5.0
        40       LS        0      74
        41       UD     0.74

        42       KK    B100+ B101
        43       KM    Combine B100 and B101
        44       HC        2
1                                         HEC-1 INPUT                                          PAGE  2

       LINE      ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10
```

```
          45           KKR101-103
          46           KM   Route from 101 to 103
          47           RM      5.0     1.22     0.10

          48           KK    B102
          49           KM   Subarea 102
          50           BA    3.14
          51           PB    4.25
          52           LS       0       74
          53           UD    0.66

          54           KK  Outlet
          55           KM   Combine R101-103 and B102
          56           HC       2
          57           ZZ
1
               SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE       (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

 NO.        (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  17          B100
                 V
                 V
  33       R100-101
                 .
                 .
  36             .        B101
                 .           .
                 .           .
  42          B100............
                 V
                 V
  45       R101-103
                 .
                 .
  48             .        B102
                 .           .
                 .           .
  54        Outlet............
 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1****************************************                  ****************************************
 *                                       *                  *                                      *
 *   FLOOD HYDROGRAPH PACKAGE   (HEC-1)  *                  *   U.S. ARMY CORPS OF ENGINEERS       *
 *            JAN   1997                 *                  *   HYDROLOGIC ENGINEERING CENTER      *
 *         VERSION 4.1                   *                  *        609 SECOND STREET             *
 *                                       *                  *     DAVIS, CALIFORNIA 95616          *
 *  RUN DATE   17MAR07  TIME  09:25:28   *                  *          (916) 756-1104              *
 *                                       *                  *                                      *
 ****************************************                  ****************************************



                    ***********************************************************
                    *  ALL AREAS of 23.77 sq miles                             *
                    *  Chiatovich near Walker Lake                       *
                    ***********************************************************

                    24-hr 100-year event-- Convective Storm
                    prepared by PB-Water Division for Mina Railroad Route Study

                    PREC     .927 .863 .816 .745
                    AREA      3.1  8.0 12.7 23.8

  14 IO        OUTPUT CONTROL VARIABLES
                    IPRNT          5  PRINT CONTROL
                    IPLOT          0  PLOT CONTROL
                    QSCAL         0.  HYDROGRAPH PLOT SCALE

    IT         HYDROGRAPH TIME DATA
                     NMIN         15  MINUTES IN COMPUTATION INTERVAL
                    IDATE     1    0  STARTING DATE
                    ITIME       0000  STARTING TIME
                       NQ        250  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE     3    0  ENDING DATE
                   NDTIME       1415  ENDING TIME
                   ICENT          19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                   TOTAL TIME BASE   62.25 HOURS

      ENGLISH UNITS
           DRAINAGE AREA         SQUARE MILES
```

```
PRECIPITATION DEPTH   INCHES
LENGTH, ELEVATION     FEET
FLOW                  CUBIC FEET PER SECOND
STORAGE VOLUME        ACRE-FEET
SURFACE AREA          ACRES
TEMPERATURE           DEGREES FAHRENHEIT

JP        MULTI-PLAN OPTION
            NPLAN          1  NUMBER OF PLANS

JR        MULTI-RATIO OPTION
            RATIOS OF PRECIPITATION
            1.00       .93       .86       .82       .75
```

1

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES
TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN		RATIO 1 1.00	RATIO 2 .93	RATIO 3 .86	RATIO 4 .82	RATIO 5 .75
					RATIOS APPLIED TO PRECIPITATION				
HYDROGRAPH AT +	B100	12.67	1	FLOW	2738.	2406.	2120.	1917.	1621.
				TIME	4.75	4.75	4.75	5.00	5.25
ROUTED TO +	R100-101	12.67	1	FLOW	2680.	2354.	2078.	1881.	1592.
				TIME	6.25	6.25	6.50	6.50	6.75
HYDROGRAPH AT +	B101	7.96	1	FLOW	1474.	1287.	1130.	1017.	855.
				TIME	4.50	4.75	4.75	5.00	5.25
2 COMBINED AT +	B100	20.63	1	FLOW	4031.	3539.	3120.	2817.	2381.
				TIME	5.75	6.00	6.00	6.00	6.25
ROUTED TO +	R101-103	20.63	1	FLOW	3971.	3489.	3074.	2780.	2349.
				TIME	7.25	7.25	7.25	7.50	7.50
HYDROGRAPH AT +	B102	3.14	1	FLOW	435.	377.	329.	294.	245.
				TIME	4.75	4.75	5.00	5.25	5.50
2 COMBINED AT +	Outlet	23.77	1	FLOW	4330.	3797.	3348.	3024.	2554.
				TIME	7.00	7.25	7.25	7.25	7.50

*** NORMAL END OF HEC-1 ***

```
1*****************************************                   ***************************************
 *                                       *                   *                                     *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                   *  U.S. ARMY CORPS OF ENGINEERS       *
 *             JAN   1997                *                   *  HYDROLOGIC ENGINEERING CENTER      *
 *          VERSION 4.1                  *                   *       609 SECOND STREET             *
 *                                       *                   *    DAVIS, CALIFORNIA 95616          *
 * RUN DATE   17MAR07  TIME  09:25:59    *                   *       (916) 756-1104                *
 *                                       *                   *                                     *
*****************************************                   ***************************************


                    X     X  XXXXXXX   XXXXX          X
                    X     X  X        X     X        XX
                    X     X  X        X               X
                    XXXXXXX  XXXX     X       XXXXX   X
                    X     X  X        X               X
                    X     X  X        X     X         X
                    X     X  XXXXXXX   XXXXX         XXX


  THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

  THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
  THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
  NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
  DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
  KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1                                          HEC-1 INPUT                                             PAGE  1

         LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

                      *DIAGRAM
           1          ID
           2          ID
           3          ID     *************************************************************
           4          ID     *  ALL AREAS of 13.05 sq miles                              *
           5          ID     *  Reese Watershed Nesr Walker Lake                         *
           6          ID     *************************************************************
           7          ID
           8          ID     24-hr 100-year event-- Convective Storm
           9          ID     prepared by PB-Water Division for Mina Railroad Route Study
          10          ID
          11          ID     PREC      0.926 0.891 0.843 0.813
          12          ID     AREA        3.2   5.7   9.8  13.1
 *** FREE ***
          13          IT        15        0        0      250
          14          IO         5        0        0
          15          IN        15        0        0
          16          JR     PREC   0.926    0.891    0.843    0.813

          17          KK     B100
          18          KM    Subarea 100
          19          BA     5.66
          20          PB     5.0
          21          PC     .000     .044     .087     .128     .168     .206     .243     .279     .313     .346
          22          PC     .378     .408     .437     .465     .492     .518     .543     .567     .589     .611
          23          PC     .632     .652     .671     .689     .706     .722     .738     .753     .767     .780
          24          PC     .793     .805     .816     .827     .837     .846     .855     .864     .872     .879
          25          PC     .886     .892     .898     .904     .909     .914     .919     .923     .927     .931
          26          PC     .934     .937     .940     .943     .945     .947     .949     .951     .952     .954
          27          PC     .956     .957     .958     .959     .960     .961     .962     .963     .964     .965
          28          PC     .966     .967     .968     .969     .969     .970     .971     .972     .974     .975
          29          PC     .976     .977     .978     .980     .982     .983     .985     .987     .989     .991
          30          PC     .993     .995     .996     .997     .998     1.00
          31          LS        0       74
          32          UD     0.79

          33          KKR100-101
          34          KM    Route from 100 to 101
          35          RM      5.0     1.36     0.10

          36          KK     B101
          37          KM    Subarea 101
          38          BA     4.16
          39          PB     4.75
          40          LS        0       74
          41          UD     0.71

          42          KK     B100+ B101
          43          KM    Combine B100 and B101
          44          HC        2
1                                          HEC-1 INPUT                                             PAGE  2

         LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10
```

```
              45           KKR101-103
              46           KM   Route from 101 to 103
              47           RM     5.0    1.36    0.10

              48           KK    B102
              49           KM   Subarea 102
              50           BA    3.23
              51           PB    3.75
              52           LS      0        74
              53           UD    0.71

              54           KK  Outlet
              55           KM   Combine R101-103 and B102
              56           HC       2
              57           ZZ
1
                 SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
  LINE       (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

  NO.        (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

   17          B100
                  V
                  V
   33      R100-101
                  .
                  .
   36             .          B101
                  .             .
                  .             .
   42          B100............
                  V
                  V
   45      R101-103
                  .
                  .
   48             .          B102
                  .             .
                  .             .
   54        Outlet............
 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************                                ****************************************
 *                                       *                                *                                      *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                                *    U.S. ARMY CORPS OF ENGINEERS      *
 *              JAN    1997              *                                *    HYDROLOGIC ENGINEERING CENTER     *
 *            VERSION 4.1                *                                *         609 SECOND STREET            *
 *                                       *                                *      DAVIS, CALIFORNIA 95616         *
 *   RUN DATE   17MAR07  TIME  09:25:59  *                                *          (916) 756-1104              *
 *                                       *                                *                                      *
 *****************************************                                ****************************************



                                *****************************************************************
                                *  ALL AREAS of 13.05 sq miles                                  *
                                *  Reese Watershed Nesr Walker Lake                         *
                                *****************************************************************

                                24-hr 100-year event-- Convective Storm
                                prepared by PB-Water Division for Mina Railroad Route Study

                                PREC     0.926 0.891 0.843 0.813
                                AREA       3.2   5.7   9.8  13.1

   14 IO          OUTPUT CONTROL VARIABLES
                        IPRNT           5  PRINT CONTROL
                        IPLOT           0  PLOT CONTROL
                        QSCAL          0.  HYDROGRAPH PLOT SCALE

      IT          HYDROGRAPH TIME DATA
                         NMIN          15  MINUTES IN COMPUTATION INTERVAL
                        IDATE      1    0  STARTING DATE
                        ITIME        0000  STARTING TIME
                           NQ         250  NUMBER OF HYDROGRAPH ORDINATES
                       NDDATE      3    0  ENDING DATE
                       NDTIME        1415  ENDING TIME
                        ICENT          19  CENTURY MARK

                  COMPUTATION INTERVAL     .25 HOURS
                       TOTAL TIME BASE   62.25 HOURS

          ENGLISH UNITS
               DRAINAGE AREA          SQUARE MILES
```

PRECIPITATION DEPTH	INCHES
LENGTH, ELEVATION	FEET
FLOW	CUBIC FEET PER SECOND
STORAGE VOLUME	ACRE-FEET
SURFACE AREA	ACRES
TEMPERATURE	DEGREES FAHRENHEIT

JP MULTI-PLAN OPTION
NPLAN 1 NUMBER OF PLANS

JR MULTI-RATIO OPTION
RATIOS OF PRECIPITATION
.93 .89 .84 .81

1

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES
TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN		RATIOS APPLIED TO PRECIPITATION RATIO 1 .93	RATIO 2 .89	RATIO 3 .84	RATIO 4 .81
HYDROGRAPH AT +	B100	5.66	1	FLOW	911.	849.	767.	717.
				TIME	4.75	4.75	5.00	5.00
ROUTED TO +	R100-101	5.66	1	FLOW	894.	834.	754.	705.
				TIME	6.25	6.25	6.50	6.50
HYDROGRAPH AT +	B101	4.16	1	FLOW	613.	571.	514.	480.
				TIME	4.75	4.75	4.75	5.00
2 COMBINED AT +	B100	9.82	1	FLOW	1467.	1368.	1236.	1155.
				TIME	5.75	6.00	6.00	6.00
ROUTED TO +	R101-103	9.82	1	FLOW	1441.	1343.	1214.	1135.
				TIME	7.25	7.25	7.50	7.50
HYDROGRAPH AT +	B102	3.23	1	FLOW	303.	281.	251.	233.
				TIME	5.25	5.25	5.50	5.50
2 COMBINED AT +	Outlet	13.05	1	FLOW	1701.	1585.	1431.	1336.
				TIME	7.00	7.25	7.25	7.25

*** NORMAL END OF HEC-1 ***

```
1****************************************          ****************************************
 *                                      *          *                                      *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *          *  U.S. ARMY CORPS OF ENGINEERS        *
 *            JAN    1997               *          *  HYDROLOGIC ENGINEERING CENTER       *
 *           VERSION 4.1                *          *       609 SECOND STREET              *
 *                                      *          *    DAVIS, CALIFORNIA 95616           *
 *  RUN DATE    17MAR07   TIME  09:25:38 *          *       (916) 756-1104                 *
 *                                      *          *                                      *
****************************************          ****************************************


                    X     X  XXXXXXX   XXXXX           X
                    X     X  X        X     X         XX
                    X     X  X        X                X
                    XXXXXXX  XXXX     X         XXXXX  X
                    X     X  X        X                X
                    X     X  X        X     X          X
                    X     X  XXXXXXX   XXXXX          XXX


      THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

      THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
      THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
      NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
      DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
      KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1                                              HEC-1 INPUT                                              PAGE  1

          LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

                      *DIAGRAM
            1         ID
            2         ID
            3         ID     **************************************************************
            4         ID     *  ALL AREAS of 40.82 sq miles                                *
            5         ID     *  Desert Creek Watershed Near Walker Lake                    *
            6         ID     **************************************************************
            7         ID
            8         ID     24-hr 100-year event-- Convective Storm
            9         ID     prepared by PB-Water Division for Mina Railroad Route Study
           10         ID
           11         ID     PREC     0.880 0.839 0.757 0.716 0.693
           12         ID     AREA       6.5  10.2  21.4  31.7  40.8
   *** FREE ***
           13         IT       15       0       0     250
           14         IO        5       0       0
           15         IN       15       0       0
           16         JR     PREC   0.880   0.839   0.757   0.716   0.693

           17         KK     B100
           18         KM    Subarea 100
           19         BA    14.92
           20         PB      6.5
           21         PC     .000    .044    .087    .128    .168    .206    .243    .279    .313    .346
           22         PC     .378    .408    .437    .465    .492    .518    .543    .567    .589    .611
           23         PC     .632    .652    .671    .689    .706    .722    .738    .753    .767    .780
           24         PC     .793    .805    .816    .827    .837    .846    .855    .864    .872    .879
           25         PC     .886    .892    .898    .904    .909    .914    .919    .923    .927    .931
           26         PC     .934    .937    .940    .943    .945    .947    .949    .951    .952    .954
           27         PC     .956    .957    .958    .959    .960    .961    .962    .963    .964    .965
           28         PC     .966    .967    .968    .969    .969    .970    .971    .972    .974    .975
           29         PC     .976    .977    .978    .980    .982    .983    .985    .987    .989    .991
           30         PC     .993    .995    .996    .997    .998    1.00
           31         LS        0      74
           32         UD     1.19

           33         KKR100-101
           34         KM    Route from 100 to 101
           35         RM      5.0    3.16    0.10

           36         KK     B101
           37         KM    Subarea 101
           38         BA     6.52
           39         PB      6.5
           40         LS        0      74
           41         UD     1.25

           42         KK     B101+ R100
           43         KM    Combine B100 and B101
           44         HC        2
1                                              HEC-1 INPUT                                              PAGE  2

          LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10
```

```
 45           KKR101-102
 46           KM   Route from 101 to 102
 47           RM      5.0     0.90     0.10

 48           KK    B102
 49           KM   Subarea 102
 50           BA   10.22
 51           PB    6.25
 52           LS       0        74
 53           UD    1.06

 54           KK    B102+ R101
 55           KM   Combine B102 and B101
 56           HC       2

 57           KKR102-103
 58           KM   Route from 102 to 103
 59           RM      7.0     2.40     0.10

 60           KK    B103
 61           KM   Subarea 103
 62           BA    9.16
 63           PB    5.75
 64           LS       0        74
 65           UD    1.04

 66           KK  Outlet
 67           KM   Combine B103+R102
 68           HC       2
 69           ZZ
```

```
1
                 SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
  LINE       (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

  NO.        (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  17          B100
                 V
                 V
  33       R100-101
                 .
                 .
                 .         B101
                 .            .
                 .            .
  42          B101............
                 V
                 V
  45       R101-102
                 .
                 .
  48             .         B102
                 .            .
                 .            .
  54          B102............
                 V
                 V
  57       R102-103
                 .
                 .
  60             .         B103
                 .            .
                 .            .
  66        Outlet............

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```

```
1****************************************                     ****************************************
*                                       *                     *                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                     *    U.S. ARMY CORPS OF ENGINEERS      *
*              JAN   1997               *                     *    HYDROLOGIC ENGINEERING CENTER     *
*            VERSION 4.1                *                     *          609 SECOND STREET           *
*                                       *                     *       DAVIS, CALIFORNIA 95616        *
*  RUN DATE   17MAR07  TIME  09:25:38   *                     *           (916) 756-1104             *
*                                       *                     *                                      *
*****************************************                     ****************************************
```

```
*************************************************************
*  ALL AREAS of 40.82 sq miles                              *
*  Sweetwater Watershed Near Walker Lake              *
*************************************************************

24-hr 100-year event-- Convective Storm
```

```
                    prepared by PB-Water Division for Mina Railroad Route Study

                    PREC     0.880 0.839 0.757 0.716 0.693
                    AREA       6.5  10.2  21.4  31.7  40.8

 14 IO         OUTPUT CONTROL VARIABLES
                    IPRNT            5  PRINT CONTROL
                    IPLOT            0  PLOT CONTROL
                    QSCAL           0.  HYDROGRAPH PLOT SCALE

    IT         HYDROGRAPH TIME DATA
                    NMIN            15  MINUTES IN COMPUTATION INTERVAL
                    IDATE       1    0  STARTING DATE
                    ITIME         0000  STARTING TIME
                       NQ          250  NUMBER OF HYDROGRAPH ORDINATES
                    NDDATE      3    0  ENDING DATE
                    NDTIME        1415  ENDING TIME
                    ICENT           19  CENTURY MARK

                  COMPUTATION INTERVAL      .25 HOURS
                      TOTAL TIME BASE     62.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA            SQUARE MILES
            PRECIPITATION DEPTH      INCHES
            LENGTH, ELEVATION        FEET
            FLOW                     CUBIC FEET PER SECOND
            STORAGE VOLUME           ACRE-FEET
            SURFACE AREA             ACRES
            TEMPERATURE              DEGREES FAHRENHEIT

    JP         MULTI-PLAN OPTION
                    NPLAN            1  NUMBER OF PLANS

    JR         MULTI-RATIO OPTION
                  RATIOS OF PRECIPITATION
                  .88        .84        .76        .72        .69
1
```

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES
TIME TO PEAK IN HOURS

					RATIOS APPLIED TO PRECIPITATION				
OPERATION	STATION	AREA	PLAN		RATIO 1 .88	RATIO 2 .84	RATIO 3 .76	RATIO 4 .72	RATIO 5 .69
HYDROGRAPH AT +	B100	14.92	1	FLOW	3353.	3097.	2595.	2354.	2220.
				TIME	5.00	5.25	5.25	5.50	5.50
ROUTED TO +	R100-101	14.92	1	FLOW	3058.	2826.	2371.	2152.	2031.
				TIME	8.75	8.75	9.00	9.00	9.00
HYDROGRAPH AT +	B101	6.52	1	FLOW	1459.	1347.	1129.	1024.	965.
				TIME	5.25	5.25	5.50	5.50	5.50
2 COMBINED AT +	B101	21.44	1	FLOW	4111.	3800.	3193.	2896.	2734.
				TIME	8.00	8.25	8.25	8.25	8.50
ROUTED TO +	R101-102	21.44	1	FLOW	4090.	3779.	3175.	2882.	2719.
				TIME	9.00	9.00	9.25	9.25	9.25
HYDROGRAPH AT +	B102	10.22	1	FLOW	2175.	2006.	1676.	1517.	1429.
				TIME	5.00	5.00	5.25	5.25	5.25
2 COMBINED AT +	B102	31.66	1	FLOW	5517.	5098.	4285.	3889.	3669.
				TIME	8.25	8.25	8.50	8.50	8.50
ROUTED TO +	R102-103	31.66	1	FLOW	5395.	4987.	4190.	3804.	3590.
				TIME	10.75	10.75	11.00	11.00	11.00
HYDROGRAPH AT +	B103	9.16	1	FLOW	1693.	1557.	1295.	1169.	1100.
				TIME	5.00	5.25	5.25	5.50	5.50
2 COMBINED AT +	Outlet	40.82	1	FLOW	6175.	5707.	4792.	4348.	4103.
				TIME	10.25	10.25	10.25	10.50	10.50

*** NORMAL END OF HEC-1 ***

```
1***************************************                     ***************************************
*                                     *                     *                                     *
*   OOD HYDROGRAPH PACKAGE  (HEC-1)   *                     *   U.S. ARMY CORPS OF ENGINEERS      *
*            JAN   1997               *                     *   HYDROLOGIC ENGINEERING CENTER     *
*         VERSION 4.1                 *                     *        609 SECOND STREET            *
*                                     *                     *     DAVIS, CALIFORNIA 95616         *
*  RUN DATE   17MAR07  TIME  09:25:48 *                     *         (916) 756-1104              *
*                                     *                     *                                     *
***************************************                     ***************************************


                  X     X  XXXXXXX   XXXXX           X
                  X     X  X        X     X         XX
                  X     X  X        X                X
                  XXXXXXX  XXXX     X         XXXXX  X
                  X     X  X        X                X
                  X     X  X        X     X          X
                  X     X  XXXXXXX   XXXXX          XXX


     THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

     THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
     THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
     NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
     DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
     KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1                                       HEC-1 INPUT                                                 PAGE  1

     LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

                   *DIAGRAM
       1           ID
       2           ID
       3           ID    *************************************************************
       4           ID    *  ALL AREAS of 519.6 sq miles                                *
       5           ID    *  Hoye Watershed Near Walker Lake                          *
       6           ID    *************************************************************
       7           ID
       8           ID    24-hr 100-year event-- Convective Storm
       9           ID    prepared by PB-Water Division for Mina Railroad Route Study
      10           ID
      11           ID    PREC    0.664 0.636 0.578 0.525 0.441 0.419
      12           ID    AREA      61.  93.2 181.2 274.4 458.6 519.6
*** FREE ***
      13           IT      15       0       0     250
      14           IO       5       0       0
      15           IN      15       0       0
      16           JR    PREC   0.664   0.636   0.578   0.525   0.441    0.38

      17           KK    B100
      18           KM   Subarea 100
      19           BA   181.2
      20           PB     6.5
      21           PC    .000    .044    .087    .128    .168    .206    .243    .279    .313    .346
      22           PC    .378    .408    .437    .465    .492    .518    .543    .567    .589    .611
      23           PC    .632    .652    .671    .689    .706    .722    .738    .753    .767    .780
      24           PC    .793    .805    .816    .827    .837    .846    .855    .864    .872    .879
      25           PC    .886    .892    .898    .904    .909    .914    .919    .923    .927    .931
      26           PC    .934    .937    .940    .943    .945    .947    .949    .951    .952    .954
      27           PC    .956    .957    .958    .959    .960    .961    .962    .963    .964    .965
      28           PC    .966    .967    .968    .969    .969    .970    .971    .972    .974    .975
      29           PC    .976    .977    .978    .980    .982    .983    .985    .987    .989    .991
      30           PC    .993    .995    .996    .997    .998    1.00
      31           LS       0      74
      32           UD    2.37

      33           KKR100-101
      34           KM   Route from 100 to 101
      35           RM    15.0    4.52    0.10

      36           KK    B101
      37           KM   Subarea 101
      38           BA   93.22
      39           PB     6.0
      40           LS       0      74
      41           UD    1.58

      42           KK    B101+ R100
      43           KM   Combine B100 and B101
      44           HC       2
1                                       HEC-1 INPUT                                                 PAGE  2

     LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10
```

```
          45           KKR101-102
          46           KM   Route from 101 to 102
          47           RM    25.0     7.23     0.10

          48           KK    B102
          49           KM   Subarea 102
          50           BA  184.18
          51           PB     4.0
          52           LS       0       74
          53           UD    2.15

          54           KK    B102+ R101
          55           KM   Combine B102 and B101
          56           HC       2

          57           KKR102-103
          58           KM   Route from 102 to 103
          59           RM     3.0     0.90     0.10

          60           KK    B103
          61           KM   Subarea 103
          62           BA   61.02
          63           PB    5.00
          64           LS       0       74
          65           UD    1.47

          66           KK  Outlet
          67           KM   Combine B103+R102
          68           HC       2
          69           ZZ
1
               SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
  LINE       (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

  NO.        (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  17          B100
                 V
                 V
  33     R100-101
                 .
                 .
                 .      B101
                 .          .
                 .          .
  42          B101...........
                 V
                 V
  45     R101-102
                 .
                 .
  48             .      B102
                 .          .
                 .          .
  54          B102...........
                 V
                 V
  57     R102-103
                 .
                 .
  60             .      B103
                 .          .
                 .          .
  66       Outlet...........

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************
 *                                       *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
 *              JAN   1997               *
 *           VERSION 4.1                 *
 *                                       *
 *  RUN DATE   17MAR07  TIME  09:25:48   *
 *                                       *
 *****************************************

 *****************************************
 *                                       *
 *    U.S. ARMY CORPS OF ENGINEERS       *
 *    HYDROLOGIC ENGINEERING CENTER      *
 *          609 SECOND STREET            *
 *       DAVIS, CALIFORNIA 95616         *
 *           (916) 756-1104              *
 *                                       *
 *****************************************


      **********************************************************
      *  ALL AREAS of 519.6 sq miles                           *
      *  Hoye Watershed Near Walker Lake                 *
      **********************************************************

      24-hr 100-year event-- Convective Storm
```

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                prepared by PB-Water Division for Mina Railroad Route Study

                PREC     0.664 0.636 0.578 0.525 0.441 0.419
                AREA       61.  93.2 181.2 274.4 458.6 519.6

14 IO        OUTPUT CONTROL VARIABLES
                   IPRNT           5  PRINT CONTROL
                   IPLOT           0  PLOT CONTROL
                   QSCAL          0.  HYDROGRAPH PLOT SCALE

   IT        HYDROGRAPH TIME DATA
                    NMIN          15  MINUTES IN COMPUTATION INTERVAL
                   IDATE      1    0  STARTING DATE
                   ITIME        0000  STARTING TIME
                      NQ         250  NUMBER OF HYDROGRAPH ORDINATES
                  NDDATE      3    0  ENDING DATE
                  NDTIME        1415  ENDING TIME
                   ICENT          19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                   TOTAL TIME BASE   62.25 HOURS

       ENGLISH UNITS
            DRAINAGE AREA          SQUARE MILES
            PRECIPITATION DEPTH    INCHES
            LENGTH, ELEVATION      FEET
            FLOW                   CUBIC FEET PER SECOND
            STORAGE VOLUME         ACRE-FEET
            SURFACE AREA           ACRES
            TEMPERATURE            DEGREES FAHRENHEIT

   JP        MULTI-PLAN OPTION
                   NPLAN           1  NUMBER OF PLANS

   JR        MULTI-RATIO OPTION
                RATIOS OF PRECIPITATION
                 .66       .64       .58       .52       .44       .38
1
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PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES
TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN		RATIOS APPLIED TO PRECIPITATION RATIO 1 .66	RATIO 2 .64	RATIO 3 .58	RATIO 4 .52	RATIO 5 .44	RATIO 6 .38
HYDROGRAPH AT +	B100	181.20	1	FLOW	22502.	20790.	17376.	14397.	10032.	7181.
				TIME	7.25	7.25	7.50	7.75	8.00	8.25
ROUTED TO +	R100-101	181.20	1	FLOW	21509.	19878.	16619.	13771.	9599.	6872.
				TIME	12.00	12.00	12.25	12.50	12.75	13.00
HYDROGRAPH AT +	B101	93.22	1	FLOW	10722.	9877.	8201.	6745.	4628.	3264.
				TIME	6.25	6.25	6.50	6.75	7.00	7.50
2 COMBINED AT +	B101	274.42	1	FLOW	26482.	24469.	20431.	16914.	11747.	8382.
				TIME	11.25	11.50	11.50	11.75	12.00	12.50
ROUTED TO +	R101-102	274.42	1	FLOW	25094.	23190.	19365.	16033.	11138.	7946.
				TIME	18.75	18.75	19.00	19.00	19.50	19.75
HYDROGRAPH AT +	B102	184.18	1	FLOW	8783.	7969.	6358.	4999.	3098.	1945.
				TIME	8.00	8.00	8.25	8.50	9.00	9.50
2 COMBINED AT +	B102	458.60	1	FLOW	26039.	24053.	20076.	16610.	11518.	8200.
				TIME	18.50	18.75	18.75	19.00	19.25	19.75
ROUTED TO +	R102-103	458.60	1	FLOW	25896.	23921.	19962.	16509.	11453.	8155.
				TIME	19.50	19.50	19.75	20.00	20.25	20.50
HYDROGRAPH AT +	B103	61.02	1	FLOW	4963.	4546.	3714.	3002.	1984.	1343.
				TIME	6.50	6.50	6.75	7.00	7.25	7.75
2 COMBINED AT +	Outlet	519.62	1	FLOW	26217.	24221.	20219.	16733.	11624.	8287.
				TIME	19.50	19.50	19.75	20.00	20.25	20.50

*** NORMAL END OF HEC-1 ***

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1*****************************************                       ***************************************
 *                                       *                       *                                     *
 *   OOD HYDROGRAPH PACKAGE   (HEC-1)    *                       *   U.S. ARMY CORPS OF ENGINEERS      *
 *             JAN   1997                *                       *   HYDROLOGIC ENGINEERING CENTER     *
 *          VERSION 4.1                  *                       *         609 SECOND STREET           *
 *                                       *                       *     DAVIS, CALIFORNIA 95616         *
 *  RUN DATE   17MAR07  TIME   09:26:10  *                       *         (916) 756-1104              *
 *                                       *                       *                                     *
*****************************************                       ***************************************


                    X     X  XXXXXXX   XXXXX          X
                    X     X  X        X     X        XX
                    X     X  X        X               X
                    XXXXXXX  XXXX     X        XXXXX  X
                    X     X  X        X               X
                    X     X  X        X     X         X
                    X     X  XXXXXXX   XXXXX         XXX


      THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

      THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
      THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
      NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
      DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
      KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1                                               HEC-1 INPUT                                               PAGE  1

    LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

                *DIAGRAM
      1         ID
      2         ID
      3         ID      ***************************************************************
      4         ID      *  ALL AREAS of 480.28 sq miles                                 *
      5         ID      *  Sweetwater Watershed Near Walker Lake                 *
      6         ID      ***************************************************************
      7         ID
      8         ID      24-hr 100-year event-- Convective Storm
      9         ID      prepared by PB-Water Division for Mina Railroad Route Study
     10         ID
     11         ID      PREC    0.603  0.592 0.578 0.493 0.433
     12         ID      AREA     141    158    181  339.5 480.0
 *** FREE ***
     13         IT      15       0       0     250
     14         IO       5       0       0
     15         IN      15       0       0
     16         JR    PREC   0.603   0.592   0.578   0.493   0.433

     17         KK    B100
     18         KM   Subarea 100
     19         BA  181.18
     20         PB     5.0
     21         PC    .000    .044    .087    .128    .168    .206    .243    .279    .313    .346
     22         PC    .378    .408    .437    .465    .492    .518    .543    .567    .589    .611
     23         PC    .632    .652    .671    .689    .706    .722    .738    .753    .767    .780
     24         PC    .793    .805    .816    .827    .837    .846    .855    .864    .872    .879
     25         PC    .886    .892    .898    .904    .909    .914    .919    .923    .927    .931
     26         PC    .934    .937    .940    .943    .945    .947    .949    .951    .952    .954
     27         PC    .956    .957    .958    .959    .960    .961    .962    .963    .964    .965
     28         PC    .966    .967    .968    .969    .969    .970    .971    .972    .974    .975
     29         PC    .976    .977    .978    .980    .982    .983    .985    .987    .989    .991
     30         PC    .993    .995    .996    .997    .998    1.00
     31         LS       0      74
     32         UD    2.49

     33         KK    B101
     34         KM   Subarea 101
     35         BA  158.07
     36         PB     6.0
     37         LS       0      74
     38         UD    2.57

     39         KK    B100+ B101
     40         KM   Combine B100 and B101
     41         HC       2

     42         KKR101-103
     43         KM   Route from 101 to 103
     44         RM    20.0    5.43    0.10
1                                               HEC-1 INPUT                                               PAGE  2

    LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10
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```
          45            KK    B102
          46            KM   Subarea 102
          47            BA  141.03
          48            PB     5.0
          49            LS       0       74
          50            UD    1.78

          51            KK  Outlet
          52            KM   Combine R101-103 and B102
          53            HC       2
          54            ZZ
1
              SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
  LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

  NO.       (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

   17        B100
              .
              .
   33         .         B101
              .            .
              .            .
   39        B100...........
              V
              V
   42      R101-103
              .
              .
   45         .         B102
              .            .
              .            .
   51       Outlet...........

 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************
 *                                       *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
 *              JAN   1997               *
 *            VERSION 4.1                *
 *                                       *
 *  RUN DATE   17MAR07  TIME  09:26:10   *
 *                                       *
 *****************************************

 *****************************************
 *                                       *
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 *            (916) 756-1104             *
 *                                       *
 *****************************************


                     ************************************************************
                     *  ALL AREAS of 480.28 sq miles                            *
                     *  Sweetwater Watershed Near Walker Lake                   *
                     ************************************************************

                     24-hr 100-year event-- Convective Storm
                     prepared by PB-Water Division for Mina Railroad Route Study

                     PREC    0.603  0.592 0.578 0.493 0.433
                     AREA     141    158    181  339.5 480.0

   14 IO          OUTPUT CONTROL VARIABLES
                        IPRNT           5  PRINT CONTROL
                        IPLOT           0  PLOT CONTROL
                        QSCAL          0.  HYDROGRAPH PLOT SCALE

      IT          HYDROGRAPH TIME DATA
                         NMIN          15  MINUTES IN COMPUTATION INTERVAL
                        IDATE      1    0  STARTING DATE
                        ITIME        0000  STARTING TIME
                           NQ         250  NUMBER OF HYDROGRAPH ORDINATES
                       NDDATE      3    0  ENDING DATE
                       NDTIME        1415  ENDING TIME
                        ICENT          19  CENTURY MARK

                COMPUTATION INTERVAL     .25 HOURS
                     TOTAL TIME BASE   62.25 HOURS

         ENGLISH UNITS
             DRAINAGE AREA          SQUARE MILES
             PRECIPITATION DEPTH    INCHES
             LENGTH, ELEVATION      FEET
             FLOW                   CUBIC FEET PER SECOND
             STORAGE VOLUME         ACRE-FEET
             SURFACE AREA           ACRES
             TEMPERATURE            DEGREES FAHRENHEIT
```

```
JP          MULTI-PLAN OPTION
                  NPLAN            1  NUMBER OF PLANS

 R          MULTI-RATIO OPTION
               RATIOS OF PRECIPITATION
                 .60       .59       .58       .49       .43
1
```

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES
TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN		RATIO 1 .60	RATIO 2 .59	RATIO 3 .58	RATIO 4 .49	RATIO 5 .43
HYDROGRAPH AT +	B100	181.18	1	FLOW	11047.	10622.	10095.	7071.	5158.
				TIME	8.00	8.00	8.25	8.50	8.75
HYDROGRAPH AT +	B101	158.07	1	FLOW	13835.	13344.	12734.	9193.	6914.
				TIME	7.75	8.00	8.00	8.25	8.50
2 COMBINED AT +	B100	339.25	1	FLOW	24875.	23966.	22821.	16245.	12055.
				TIME	8.00	8.00	8.00	8.25	8.75
ROUTED TO +	R101-103	339.25	1	FLOW	23752.	22878.	21793.	15523.	11517.
				TIME	13.50	13.50	13.75	14.00	14.25
HYDROGRAPH AT +	B102	141.03	1	FLOW	9152.	8799.	8361.	5854.	4271.
				TIME	7.00	7.00	7.25	7.50	7.75
2 COMBINED AT +	Outlet	480.28	1	FLOW	27221.	26216.	24962.	17726.	13110.
				TIME	13.00	13.25	13.25	13.50	13.75

*** NORMAL END OF HEC-1 ***